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ABSTRACT

A study sought to develop and evaluate an instructional model which utilized the computer to produce individually prescribed instructional guides to account for the idiosyncratic variations among students in physics classes at the secondary school level. The students in the treatment groups were oriented toward the practices of selecting behavioral objectives from objective planning sheets, using computer-produced instructional guides, and accepting individual responsibility for learning. When achievement level was measured by a group achievement test, no significant difference was found between control and treatment groups. However when achievement level was measured by the number of objectives mastered, the treatment groups did significantly better. Neither learning efficiency nor attitudes toward the physics course was significantly changed by utilizing an individualized teaching model. (JY)

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A METHODOLOGICAL STUDY EVALUATING A PRETUTORIAL COMPUTER-COMPILED INSTRUCTIONAL PROGRAM IN HIGH SCHOOL PHYSICS INSTRUCTION INITIATED FROM STUDENT-TEACHER SELECTED INSTRUCTIONAL OBJECTIVES

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ABSTRACT

The purpose of this study was to develop and evaluate an instructional model which utilized the computer to produce individually prescribed instructional guides to account for the idiosyncratic variations among students in physics classes at the secondary school level.

One instructor was responsible for directing the learning activities in physics to three scheduled classes. Of these, two were selected by random techniques to serve as the treatment groups, e.g., individualized and traditional. An orientation phase of twelve weeks duration was utilized to enable the students in the experimental group to become accustomed to techniques unique to the individualized instructional model. The student s were oriented to the practices of selecting behavioral objectives from objective planning sheets, using computer-produced instructional guides, and accepting individual responsibility for learning. At the conclusion of the orientation phase, the treatment phase commenced with an achievement pretest in physics. The concepts, principles, and examples of two chapters in the P. S. S. C. text served as the principal content source during the treatment phase for both treatment groups. Chapter tests developed by utilizing each student's objectives were administered at the conclusion of each chapter to both groups. The conclusion of the treatment phase was signified by the administration of an attitude questionnaire and the post-achievement test. The temporal span of the treatment phase was five weeks.

The criterion variable for statistical hypotheses 1, 3, and 5 was the student's score on the physics achievement test. The dependent variable for statistical hypotheses 2 and 4 was the student's attitude score and the frequency of objectives mastered, respectively.

The independent variable for statistical hypotheses 1, 2, 3, and 4 was the type of treatment administered, while in hypothesis 5 the independent variables were identified as the nine selected idiographic factors used to generate the student study guides.

Analysis of covariance with pretest measures serving as the covariant was used to test hypothesis 1. Statistical hypotheses 2 and 3 were tested by using the analysis of variance statistic. Hypothesis 4 was evaluated with the 2 x 2 chi-square statistic, while multiple correlation was applied to the data to evaluate hypothesis 5.

To the degree that it is possible to generalize from the analysis of the collected data from this study, the stated purpose was achieved to the extent expressed by the ensuing conclusions.

1. The achievement level of individual high school students enrolled in physics, as measured by an achievement test designed to evaluate groups of

students enrolled in secondary school physics, is not significantly increased by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.

2. The achievement level of high school students of physics, as indicated by the number of objectives mastered, can be significantly increased by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.
3. The learning efficiency, as defined in this study, of high school students of physics is not significantly increased by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.
4. The attitudes toward the course of physics expressed by high school physics students who have previously received group instruction do not change significantly by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.

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Chapter 1

INTRODUCTION

The theoretical orientation of individualized instruction is difficult to isolate because of an absence in literature of stated theories of teaching. De Cecco has established that a theory of teaching should consider three questions: these are, "How teachers behave, why they behave as they do, and with what effects."[1] Gage has indicated that teaching embraces too many varied processes, behaviors, and activities to be the proper subject of a single theory.[2] In contrast, theories of learning are numerous and do describe the conditions under which learning does and does not take place. A theory of learning is a general concept which applies to all organisms, to all learning tasks, to all situations, in formal and informal learning settings. This definition conveys the idea that a learning theory is much broader and more basic than a theory of teaching.[3]

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[1] John P. De Cecco, The Psychology of Learning and Instruction (Englewood Cliffs: Prentice-Hall, 1968), p. 7.

[2] N. L. Gage, "Paradigms for Research on Teaching," Handbook of Research on Teaching, N. L. Gage (ed.) (Chicago: Rand McNally, 1963), p. 134.

[3] David Ausubel, Educational Psychology: A Cognitive View (New York: Holt, Rinehart, and Winston, 1968), p. 11.

The best alternative now available for a theory of teaching is a model of teaching. Glaser developed a teaching model in 1962 consisting of four components: (a) analyzing the characteristics of subject-matter competence, (b) diagnosing preinstructional behavior, (c) instructional procedures, and (d) measuring learning outcomes.[4]

This model is very appropriate for not only group instruction but individualized instruction as well. William Hedges recently published a set of operational principles for "scientific teaching" which reinforced Glaser's model. The seven principles set forth by Hedges included: (a) identify prerequisite skills known by student, (b) allow enough time for learning, (c) consider every student to be an achiever, (d) let students plan their own work, (e) develop study skills for small group learning, (f) evaluation instruments based upon instructional objectives, (g) allow for fast achievers.[5] Although these principles apply to group instruction, they incorporate the rationale for individualizing instruction. In one earlier article, Hedges developed a case for individualized instruction by citing research conducted on the heterogeneity of "homogeneous" groups. In the same article, he stressed other individual variables such as: student reaction time, need for activity, intra-individual differences, and destruction of self-esteem as sources of evidence for the need of individualized instruction.[6]

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[4] Robert Glaser (offprint), The Design of Instruction, Chapter IX of Sixty-Fifth Yearbook of the National Society for the Study of Education, Part II (Chicago: National Society for the Study of Education, 1966), p. 217.

[5] William D. Hedges, "Operating Principles for Scientific Teaching," Science Senior High School Edition (Croft Educational Services), Second Quarter (1970-71), pp. 1-3.

Another model of teaching was developed by Stolurow and Davis. In this model, the computer replaced the teacher in making decisions and provided the instruction. The teaching process was divided into the pretutorial phase, which selected a teaching program for each student, and the tutorial phase, which had a two-fold purpose: teaching and evaluation. In this model, the pretutorial phase encompassed the first three components of Glaser's teaching model (objectives, diagnosis, instructional procedures), while the tutorial phase subsumed the instructional and evaluation phase. Stolurow and Davis suggest that only computers have the capacity to make all the decisions and accommodations necessary for individualizing a class or student-body of learners.[7]

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[6] William Hedges, "A Rationale for Individualizing Instruction," Hedges Letters, Letter #2 (Chicago: Science Research Associates, Inc., October 23, 1967).

[7] De Cecco, op. cit., pp. 13-15.

Notably absent in the discussions on teaching models is empirical evidence to support the value of the above models over other models, such as Carroll's model[8] based upon pacing, and Flanders' model[9] based upon social interaction. The search for empirical evidence to support a model of teaching involving individualized instruction included the researching of doctoral dissertations and abstracts. From this review of literature, a number of studies were identified and obtained. One study by Krockover reported no significant differences in achievement in groups utilizing individualized instruction in CBA chemistry compared to group instruction in CBA chemistry.[10] Other studies on individualized instruction by Paden,[11] Peterson,[12] and Williams[13] indicated a significant increase in achievement of students on individualized programs compared with traditionally taught (control) groups. Each of these studies involved subject-matter in the natural sciences with junior high or senior high school students comprising the group populations.

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[8] John B. Carroll, "Research on Teaching Foreign Languages," Handbook of Research on Teaching, N. L. Gage (ed.) (Chicago: Rand McNally, 1963), p. 1061.

[9] Edmund J. Amidon and Ned A. Flanders, The Role of the Teacher in the Classroom (Minneapolis: Association for Productive Teaching, Inc., 1967).

[10] Gerald Howard Krockover, "A Comparison of Learning Outcomes in CBA Chemistry When Group and Individualized Instruction Techniques are Employed," (unpublished Doctoral dissertation, University of Iowa, 1970), pp. 73-74. Microfilm.

Novak, Ring, and Tamir reported, from analyzing data on individualized instruction, that studies using methods which compensated for individual differences by varying the instructional techniques indicated little or no significant variations in achievement when comparisons were made with conventionally taught classes.[14]

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[11] Jon S. Paden, "An Experimental Study of Individualized Instruction in High School Physics Using the Computer to Prescribe Activities as a Function of Selected Idiographic Factors" (unpublished Doctoral dissertation, University of Missouri-Columbia, 1970), p. 83.

[12] Richard Smith Peterson, "Development and Evaluation of an Individualized Learning Unit in Science for the Junior High School" (unpublished Doctoral dissertation, University of Utah, 1970), p. 103. Microfilm.

[13] William W. Williams, "An Experimental Investigation of Individualized Instruction in the Teaching of Quantitative Physical Science" (unpublished Doctoral dissertation, Duke University, 1969), pp. 64-65. Microfilm.

[14] Joseph D. Novak, Donald G. Ring, and Pinchas Tamir, "Interpretation of Research Findings in Terms of Ausubel's Theory and Implications for Science Education" (unpublished paper at the time of acquisition, 1969), p. 13.

Purpose of the Study

The purpose of this study was to develop and evaluate an instructional model based upon individualized instruction which utilized the computer to produce individually prescribed instructional guides to account for the idiosyncratic variations among students in physics classes at the secondary level of education.

Need for the Study

In 1970, Bianchi conducted a study which involved a comparison of the differences among instructional objectives which were formulated and selected with and without the participation of students. In this study, he sought answers to the following questions: What are the differences among sets of instructional objectives which are selected for students by (a) their teachers, (b) the student, (c) the student and teacher cooperatively? Bianchi found that students chose more factual objectives and a greater number of objectives than the teacher chose for them. A comparison between the objectives which the teacher considered to be important and those considered important by their students produced little agreement. However, the student and teacher cooperative selection process resolved most of the differences. Bianchi indicated a need for replication of this study in different subject areas, grade levels, and other variables.[15]

In 1970, Paden conducted an individualized study in secondary physics instruction that utilized a computer developed study guide in the treatment phase. This guide accommodated student differences in educational progress, academic abilities, vocational interests, and attitudes toward learning activities. Paden's implications for additional study included a need for a study on individualized instruction conducted in a high school of different size and located in a different community than the site of his study. He also suggested the need for selection of different diagnostic idiographic factors to use as diagnostic tools for the student's learning program.[16]

Responding to the needs outlined above, the investigator conducted this study to increase the body of knowledge on individualized instruction; incorporating varied idiographic factors, cooperatively selected objectives, and a computer selected learning program.

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[15] Gordon P. Bianchi, "A Descriptive Comparison of the Differences Among Instructional Objectives Which are Formulated and Selected With and Without the Participation of the Students" (State University of New York at Buffalo, 1970), Dissertation Abstracts, Vol. 31 (October, 1970), p. 1678.

[16] Paden, op. cit., p. 91.

STATEMENT OF THE PROBLEM

Assumptions

Certain assumptions were made in conducting this study since it was not possible to control many of the extraneous variables.

The sample. The assignment of the students to treatment groups was not made randomly. The assumption was made that normal enrollment procedures would furnish three equal groups from which the treatment groups would be randomly selected. This assumption was verified when the variances between treatment groups, for each of the nine idiographic factors, were compared and found to be not significantly different.

Teacher. The teacher of this study was experienced with the techniques of group instruction. It was assumed that with additional effort and preplanning, the teacher would be as effective using individualized methods as he was using the group approach with which he was more familiar.

Data. One dependent variable (achievement scores in physics) was measured by a test constructed by the teacher and the investigator. The internal consistency form of reliability of this instrument was determined by application of the Kuder-Richardson formula 20 equation.

The other dependent variable on student attitude scores concerning the physics course was obtained by administering the *Purdue Master Attitude Scale for Measuring Attitude Toward Any School Subject.*[17]

Research Question

Empirical evidence to support specific teaching theories is seldom reported if not non-existent in professional literature. Due to the lack of a theoretical rationale which had a sufficient log of empirical evidence, a teaching model was adopted as the theoretical foundation of this study. Under these conditions, M. H. Marx, in *Theories of Contemporary Psychology*, recommended that research questions be cited in place of research hypotheses.[18]

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[17] H. H. Remmers, "The Purdue Master Attitude Scales," *The Sixth Mental Measurements Yearbook*, Oscar Buros (ed.) (Highland Park: Gryphon Press, 1965), p. 359.

[18] Melvin H. Marx, *Theories of Contemporary Psychology* (New York: Macmillan Company, 1963), pp. 19-20.

Principal Research Question

1. Will the teaching model which incorporates the prescribed instructional guides developed cooperatively by the teacher and student and compiled by the computer affect the achievement of the students in a high school physics class?

Secondary Research Questions

2. Will the proposed teaching model affect the students' attitudes toward the course in physics?

3. Will the proposed teaching model affect the learning efficiency of students in physics?

4. Will the number of behavioral objectives mastered by the students of the two treatment groups be equivalent?

5. Will achievement in an individualized setting be independent of the following idiographic factors of the students?

   (a) the accumulated math-science honor points since grade nine.

   (b) the reading rate and reading comprehension as measured by the Nelson-Denny Reading Test.[19]

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[19] M. J. Nelson and E. C. Denny, "Nelson-Denny Reading Test: Vocabulary-Comprehension Rate," The Sixth Mental Measurement Yearbook, Oscar Buros (ed.) (Highland Park: Gryphon Press, 1965), p. 1077.

(c) self-reliance as measured by Every Day Life: A Scale for the Measurement of Three Varieties of Self-Reliance.[20]

(d) educational progress in science, mathematics, and writing achievement as measured by the STEP instrument.[21]

(e) verbal and non-verbal ability as measured by the CTMM instrument.[22]

Definitions

1. Individually prescribed instructional guide—this printed material consisted of a set of behaviorally stated objectives and instructions to guide the student as he proceeded through the unit. This guide was compiled and printed by the computer.

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[20] Leland H. Stott, "Every Day Life: A Scale for the Measurement of Three Varieties of Self-Reliance," The Fourth Mental Measurement Yearbook, Oscar Buros (ed.) (Highland Park: Gryphon Press, 1965), p. 84.

[21] Oscar Buros, "Sequential Tests of Educational Progress," The Sixth Mental Measurements Yearbook (Highland Park: Gryphon Press, 1965), pp. 100-109.

[22] Elizabeth T. Sullivan, Willis W. Clark, and Ernest W. Tiegs, "California Short-Form Test of Mental Maturity," The Sixth Mental Measurements Yearbook, Oscar Buros (ed.) (Highland Park: Gryphon Press, 1965), p. 693.

2. Behavioral objectives—for this study each behavioral objective consisted of the following three basic components: (a) conditions of learning, (b) cognitive levels of knowledge defined by "Bloom's Taxonomy,"[23] and (c) levels of proficiency expected.

3. Objective planning sheet—a printed sheet which consisted of the content objective, six alternate levels of cognition, and three alternate levels of proficiency. The student and teacher cooperatively selected a behavioral objective for each content objective from the alternate choices of cognition and levels of proficiency.

4. Cooperatively selected objective—behavioral objectives synthesized by the student and teacher from an objective planning sheet. Students selected the level of cognition from six alternatives and the proficiency level from three alternatives.

5. Learning efficiency—ratio of performance squared to the product of ability and educational skill. The performance was measured by the achievement scores from the unit, which were converted to T scores, the ability was measured by the total score of

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[23] Benjamin S. Bloom, Taxonomy of Educational Objectives, Handbook I: Cognitive Domain (New York: David McKay Company, 1956), pp. 62-197.

the California Test of Mental Maturity, and educational skill was measured by the science scores of the Sequential Tests of Educational Progress.[24]

6. Attitudes—the feelings of students toward the course in physics were specifically what were being considered in this study. These attitudes were measured by the Purdue Master Attitude Scale to Measure Attitude Toward Any School Subject.[25]

7. Control group—one class of physics students whose treatment exemplified conventional group instruction in P. S. S. C. physics.[26] This group was randomly assigned as the control group by utilizing a table of random numbers.[27]

8. Experimental group—one class of physics students whose treatment exemplified the individualized teaching model developed for this study. The basic content for this group was

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[24] Sullivan, Clark, Tiegs, loc. cit.

[25] Remmers, loc. cit.

[26] Physical Science Study Committee, Physics (New York: D. C. Heath, 1964).

[27] The Rand Corporation, A Million Random Digits With 100, 000 Normal Digits (Glencoe: Free Press, 1955).

obtained from the P. S. S. C. text and related printed materials.[28] The experimental group was randomly assigned by utilizing a table of random numbers.[29]

9. Experimental teaching model—see Figure 1 and accompanying explanation.

Experimental Teaching Model

The cooperative effort of the teacher and student appears in Figure 1 as the initial step in the model. This step was naturally preceded by the development of the list of objectives, the collection of idiographic data on each student, and the development and requisitioning of materials for the different modes of instruction.

The cooperative effort of selecting a set of objectives depended upon student and teacher input. Student input included interests and future plans. The teacher input was based upon idiographic data of each student which included reading ability, achievement and skill in science and mathematics, self-reliance rating, and verbal and quantitative ability. The actual selection of objectives included decisions on the particular cognition level to achieve (six

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[28] P. S. S. C., op. cit., Chapters 19-20.

[29] Rand Corporation, loc. cit.

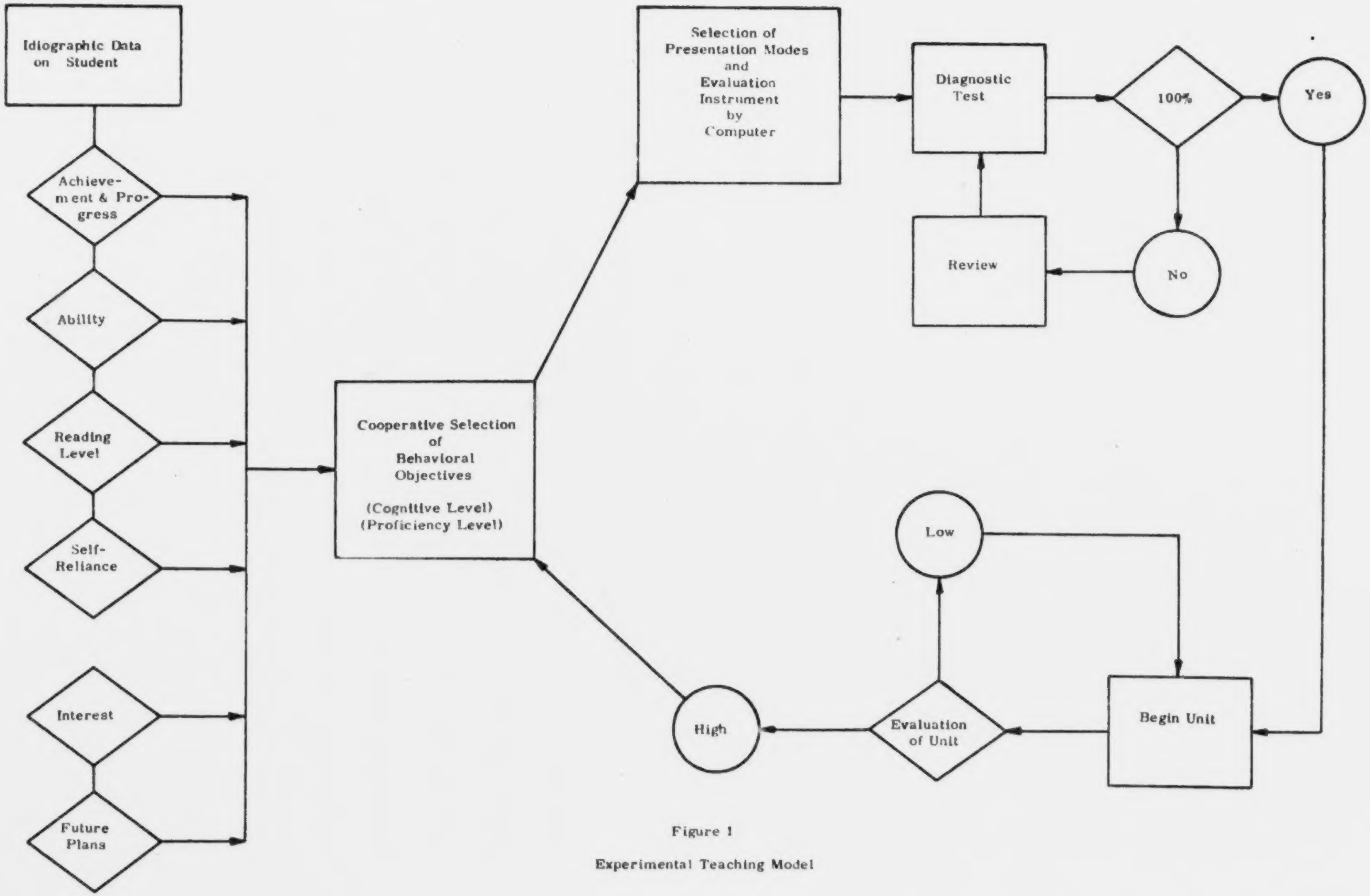
Idiographic Data on Student
Achievement & Progress
Ability
Reading Level
Self-Reliance
Interest
Future Plans
Cooperative Selection of Behavioral Objectives (Cognitive Level) (Proficiency Level)
Selection of Presentation Modes and Evaluation Instrument by Computer
Diagnostic Test
100%
Yes
No
Review
Begin Unit
Evaluation of Unit
Low
High

Figure 1

Experimental Teaching Model

levels of cognition) and decisions on the proficiency level (the extent of mastery of the objective: 100%, 80%, or 60%) to expect.

Once the objectives were selected, the student's name, address, idiographic data, and list of objectives for the learning unit were processed into data for the computer program. The computer then developed a printed set of sequential instructions to reach criterion for each objective. Included in the instructions was a recommended time limit to complete the unit.

Once the computer printout, designated as the learning guide, was produced, it was given to the student. One of the initial instructions directed the student to take a diagnostic test on that unit. The purpose of this test was to determine if the student knew the background material necessary to begin the unit of study. If the student knew the necessary prerequisite material, he proceeded with the instructions in the guide. If the diagnostic test indicated deficiencies in the student's background, the teacher referred him to materials for review. After the student demonstrated an understanding of the prerequisite materials, he was allowed to continue in the instructional program.

At the conclusion of the unit, the student was evaluated with an instrument compiled by the computer. If the student did not reach the prescribed criteria, he would recycle through the material again with alternate instructional modes suggested by the teacher.

On the other hand, if the student was successful in his first encounter with the test, he then proceeded to the list of objectives for the next unit and the entire process began again for the ensuing unit.

Limitation of the Study

The length of this study was a limitation. In order to reduce the external variance due to history and maturation, it was necessary to limit the temporal span of the experiment. In limiting the length of treatment to twenty-five days, the possible hazard of reducing the treatment to the extent no significant differences would occur was a distinct possibility. Therefore, small differences were expected when the data was analyzed.

This study was a field experiment. Therefore, it was subject to all the characteristic limitations associated with studies of this nature.

METHOD OF STUDY

Description of the Test School

The school. The David H. Hickman High School is the public high school of Columbia, Missouri. Hickman High School offers a comprehensive program for the student enrollment which exceeds two thousand for grades ten through twelve. Due to the relatively large student body, the administration has adopted the "hall" plan and the departmental structure in an attempt to provide for the individual needs of the students.

The sample. Hickman students in the eleventh or the twelfth grade are eligible to enroll in physics. Prerequisite courses in science and mathematics are not required to enroll in physics. Therefore, the students in this study varied considerably both in the quantity and the quality of their academic experience in science prior to their enrolling in the physics course. This investigation involved the sixty-nine students enrolled in physics during the 1971-72 school year. The sixty-nine students enrolled in physics were assigned to one of the three regularly scheduled classes of physics offered at Hickman High School by conventional enrollment practices. These classes were scheduled into the first three periods of the school day. From these three groups of physics students, the investigator selected two groups to serve as treatment groups for the study.

The first period class was selected by utilizing a table of random numbers as the experimental group, while the third period class was selected by the same random technique to be the control group.[30] The second period class, which was not selected as one of the treatment groups for this study, utilized the same treatment methodology as the experimental group of this study to ensure continuity of the overall physics instructional program.

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[30] Rand Corporation, loc. cit.

The Orientation Phase

The student. Traditionally, eleventh and twelfth grade students have been conditioned to a learning environment that Flanders classified as teacher-directed.[31] This environment is characterized by the teacher explaining, lecturing, and giving directions while the student learns by listening and following the teacher's instructions. An important aspect of the orientation phase was to provide the opportunity for the students to assume some responsibility for their own learning. For individualized instruction to be possible, it was necessary that each student understand the responsibilities and procedures under which the class operated.

The orientation phase (which encompassed twelve weeks) was initiated at the beginning of the 1971-72 school year. During this time, a test battery consisting of the *California Test of Mental Maturity*,[32] *Every Day Life: A Scale for the Measurement of Three*

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[31] Amidon, *op. cit.*, p. 10.

[32] Sullivan, Clark, and Tiegs, *loc. cit.*

Varieties of Self-Reliance,[33] and the Nelson-Denny Reading Test[34] was administered. The data obtained from these tests were compiled along with specific data gathered from the student's permanent record. The Sequential Test of Educational Progress[35] scores in science, mathematics, and writing achievement, and the accumulated math-science honor points since grade nine were the specific information needed from the student's permanent record. These idiographic data served a dual role in this study. Mean values were determined on each set of test scores and were used as decision points in the internal logic of the computer program to print instructions and guide statements for the students. The data also were used by the teacher to counsel each student in selecting their behavioral objectives during the experiment phase.

To gradually alter the instructional environment from the group setting, only one major change was introduced at a time. Since the students were expected to select the behavioral objectives during the experiment phase, a lesson was developed to enable each student to understand the principles of Bloom's six levels of cognition[36] and apply them to the selection of their behavioral objectives. This experience was conducted to enlighten students to the various degrees of learning and convey what was expected if that type of learning was realized. A computer-printed assignment and objective sheet including each student's name was introduced to all three classes during the fifth week of the orientation phase. Examples of this study guide appear in Appendix H. This type of computer-printed guide was used by all classes for five weeks (fifth week through ninth week) during the orientation phase. The control group continued to utilize this type of computer printout throughout the remainder of the orientation phase and through the experiment phase of this study.

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[33] Stott, loc. cit.

[34] Nelson, Denny, loc. cit.

[35] Buros, loc. cit.

The experimental group used study guides during the last three weeks of the orientation phase which had the same format and components as the individually prescribed instructional guides that were used during the experiment phase. However, these guides still contained the same set of instructions for all students. During this period of the orientation phase, the individualized mode was adopted by the experimental group.

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[36] Bloom, *loc. cit.*

The orientation phase was necessary in a methodological study of this nature to condition the student to different techniques and prepare him to accept responsibility for his learning.

The teacher. During the orientation phase, the teacher, well-versed in group instructional practices, experimented with and adopted a different instructional role. His classroom responsibility was altered from presenting the material in formal lectures, discussions, and giving directions to making himself available for student questions, preparing and setting up additional reference materials, preparing audio tape lessons, and conversing with small groups of students. One of the most difficult transitions made by the teacher while adopting the individualized mode of instruction was resisting the temptation to intervene during class and make a formal presentation.

The Experiment Phase

The experimental design. The experimental design for this study consisted of two treatment groups: experimental and control. Each group was given tests concerning physics achievement and attitudes as illustrated in Table 1. The rationale and justification for this design was found in Underwood,[37] and Campbell and Stanley.[38]

Table 1

Experimental Design for Two Treatments

Treatment	Pretest	Instructional Mode	Posttest
Experimental	Yes	Individualized	Yes
Control	Yes	Group	Yes

The content. Chapters 19 and 20 of the P. S. S. C.[39] physics course supplied the basic content taught during the treatment phase of this study. These chapters were proposed for this study because they were relatively independent of the material which preceded them. These chapters constituted the initial material on the dynamics section of the course. Specific concepts considered in these chapters included: vector addition of forces, inertial and gravitational mass, application of Newton's Law, units of force, motion in different frames of reference, and relation of forces to motion.

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[37] Benton J. Underwood, Psychological Research (New York: Appleton-Century-Crofts, Inc., 1957), pp. 147-148.

[38] Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research (Chicago: Rand McNally, 1963), pp. 47-50.

[39] P. S. S. C., loc. cit.

The two experimental chapters were organized to be taught as two units of study as shown in Table 2. The schedule allowed for each chapter was obtained from the Part III Teacher's Guide of P. S. S. C.[40] and adjusted to this model of instruction. This time allotment represented the number of days the control group spent on each chapter.

Table 2

Content Organization for the Experiment Phase

Unit	Content	Time Factor
First	Chapter 19	10 school days
Second	Chapter 20	15 school days

Pacing. As mentioned in the preceding section, the control group followed the time schedule established in Table 2, while the students who were members of the experimental group followed a recommended pacing schedule developed after the student and teacher cooperatively selected behavioral objectives for the unit being pursued. The pacing value for those students in the experimental group was determined by the computer by considering the student's idiographic data and the recommended schedule for each chapter. A flow-chart which represents the decision logic used by the computer to determine the pacing value is shown in Figure 2. The pacing value appeared on the first page of the student's instructional guide.

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[40] Physical Science Study Committee, Physics Teacher's Resource Book and Guide (New York: D. C. Heath, 1966), p. 5.

For purposes of comparison, all groups commenced with the study of Chapter 19 at the same time. Both groups were given the final achievement posttest on the twenty-fifth class day of the experiment phase to hold the length of treatment variable constant.

The only external requirement on pacing for the experimental group was the fact that the posttest was administered to all students in both groups on a set date.

Control group. The control group was taught following the procedures suggested in the P. S. S. C. teacher's guide[41] using the instructional strategy of inquiry-directed techniques which encompassed the inductive method of idea development. The control group

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[41] _Ibid._

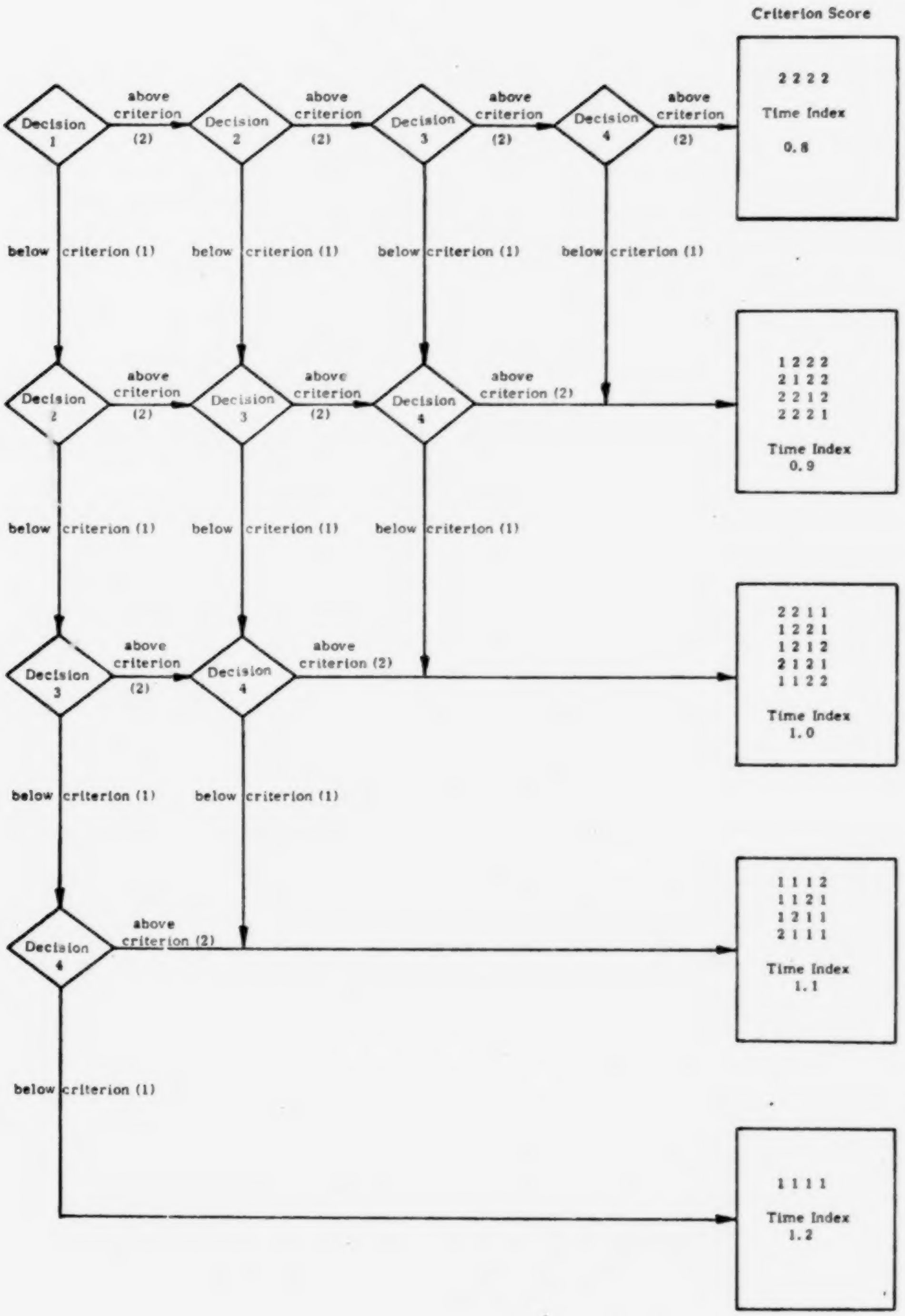
Criterion Score
Decision 1
Decision 2
Decision 3
Decision 4
above criterion (2)
below criterion (1)
2 2 2 2
Time Index 0.8
1 2 2 2
2 1 2 2
2 2 1 2
2 2 2 1
Time Index 0.9
2 2 1 1
1 2 2 1
1 2 1 2
2 1 2 1
1 1 2 2
Time Index 1.0
1 1 1 2
1 1 2 1
1 2 1 1
2 1 1 1
Time Index 1.1
1 1 1 1
Time Index 1.2

Figure 2

Flow Diagram to Illustrate the Decision Making Process for Determining the Student's Pacing Value

Decision 1: Achievement in Science-Math
Decision 2: Reading Ability
Decision 3: Self-Reliance
Decision 4: CTMM Total Score

class sessions typically included: (1) lecture and discussion, (2) group laboratory exercises, (3) problem sessions, and occasionally (4) films. The control group students were expected to participate in all normal class activities such as watching films and performing the laboratory exercises. Behavioral objectives, activities, and assignments were provided to each student in the control group via computer printed guides in an effort to reduce the aura of experimentation and perceived differential treatment between the groups. Examples of the study guide provided to students in the control group appear in Appendix H.

The instructional model for the control group is illustrated by Figure 3.

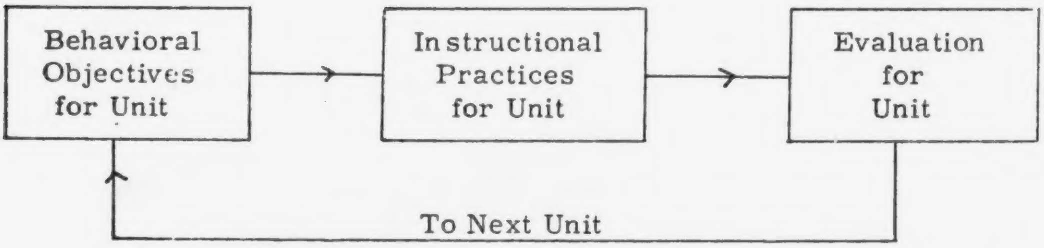
Behavioral Objectives for Unit
Instructional Practices for Unit
Evaluation for Unit
To Next Unit

Figure 3

The Instructional Model Used by the Control Group During the Experiment Phase

Experimental group. Upon entering the treatment phase of the investigation, the experimental group students had experienced the process of developing behavioral objectives from an objective planning sheet, utilized computer developed study guides whose format was like the guide to be used in the experiment phase, and had worked under the individualized mode for two weeks. With this orientation, the aura of experimentation, or the "Hawthorne Effect" was hopefully controlled for this group.

In the experimental setting, the teacher was available to the students while moving about the classroom observing, asking questions, and checking progress of each student in the group. The teacher was responsible for providing that all of the materials for learning were made readily available to the students when they were needed. He controlled the environment of the classroom in such a manner to accommodate students studying quietly as well as those involved in a laboratory exercise or small group discussion.

In addition to these general functions, the teacher facilitated the development of behavioral objectives for each unit through cooperative interaction with the student. The content objectives for both the experimental and control groups were the same. However, the behavioral objectives developed from the content objectives varied to a considerable extent between the treatment groups. In the experimental group, the idiographic data collected on each student were used by the teacher to advise the student upon the cognitive level to achieve and the proficiency level to strive for. The student's input into the formulation of these objectives was tempered by his interests, future plans, and knowledge of Bloom's Taxonomy of Cognition.[42] The selection of the behavioral objectives was facilitated by using the objective planning sheets. The objective planning sheets for chapters 19 and 20 appear in Appendix G. The selected cognitive level and proficiency level for each content objective were recorded by the student on the objective selection sheet. A copy of the objective selection sheet appears in Appendix G.

According to Figure 1 (page 15), which illustrates the model of instruction for the individuals in the experimental group, the next step after the objectives were selected was the development of the individually prescribed instructional guide for each student. The computer program which generated the instructional guides was developed by the investigator with technical assistance from Wayne Churchill, who is employed at the University of Missouri-Columbia Computer Center, and Dr. Jon S. Paden of the Charles F. Kettering Foundation. A flow diagram which illustrates the logic structure and decision making process used in printing the specific instructional steps of each student's instructional guide appears in Appendix I.

A diagnostic pretest was administered to all students in the experimental group after they received their instructional guides.

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[42] Bloom, loc. cit.

Instructions directing the students to take the diagnostic pretest appeared in the student guides. All students took the same diagnostic test for each unit. The material in these tests consisted of terms and concepts which were necessary knowledge prerequisites for entering the unit of study. For example, the terms "velocity," "mass," "acceleration," and operations such as vector addition should have been understood by the student before work in Chapter 19 commenced. If the student demonstrated an adequate knowledge of the fundamental prerequisite material, he proceeded with the study of the unit. However, if a deficiency in the student's background was indicated by the diagnostic pretest, review of those terms and concepts which were not part of the student's cognitive structures would have been necessary. The teacher then aided the student by directing him to specific references for review of the concepts and terms with which he was unfamiliar. Once the student demonstrated a knowledge of those concepts and terms, he then proceeded with the study of the unit. The diagnostic pretest for Chapters 19 and 20 appear in Appendix J.

After the student completed the unit activities suggested by the instructional guide, he was evaluated with an instrument developed specifically from the requirements specified by the behavioral objectives. This instrument was compiled and printed by the computer when the instructional guides were printed. However, a different program was responsible for this printout. If the student demonstrated that he had achieved the criteria established in the behavioral objectives, he was allowed to proceed to the next unit of study. On the other hand, if criterion was not achieved for all of the objectives, recycling through particular sections was necessary. At this point, teacher guidance was very important, because not only did the student need assistance in approaching the material from a different perspective, but re-evaluation of the behavioral objectives for that student occasionally revealed that an inappropriate objective had been initially established. A complete listing of the test items for Chapters 19 and 20, examples of Chapter 19 and 20 quizzes, and a flow diagram to illustrate the generation of a student's quiz by the computer appear in Appendix K.

Frequent references have appeared in this section to the individually prescribed instructional guide. This guide served as the organizational cement to maintain continuity and administrative structure to the open climate classroom. The task of producing twenty-four different guides for the students involved in the experimental group for each unit would have been most impractical if not impossible to achieve by utilizing available office equipment. However, by utilizing the capabilities of the computer, the guides were produced efficiently and at moderate cost.

The Individually Prescribed Instructional Guide

The guides used by the experimental group had the same format as those used by this group during the latter stages of the orientation phase. Because of this preconditioning, students experienced few adjustment problems in using the computer produced guides during the experiment phase of the study.

The learning modes or activities that were used in the learning sequence were selected by the computer from the decisions made by utilizing the idiographic data on each student and the fifteen modes or activities available for selection. Table 3 lists the modes that were used and the idiographic data to which the computer had access for making decisions with respect to the prescribed instructional guide. The student's previously demonstrated abilities were utilized in determining the study guide content. For example, learning sequences for good readers included more extensive reading assignments than did the learning sequences for poor readers. The poor reader was asked to spend more time with audio-taped lessons to compensate for his reading disability. Another example was the student with a high rating in mathematical ability. This student was usually given more problems and exercises involving a mathematical solution than his peers who had a lower ability in this area. Those students who were identified by the Every Day Life: A Scale for the

Table 3[43]

Criteria Used to Determine Appropriate Instructional Guide Modes

Learning Activities	Reading Comprehension (N-D)	Self-Reliance (Every Day Life Scale)	Science-Mathematics Achievement (Honor Points)	Verbal Ability (CTMM)	Educational Skill (STEP) Writing	CTMM—Non-verbal Ability	STEP - Science	STEP-Math	Reading Rate
Study Objectives	x		x						
Introductory Film	x								
Laboratory Exercise		x	x			x	x		
Laboratory Report		x		x	x				
Readings	x			x	x				x
Audio-tape Lesson	x		x						x
Single-concept Film	x					x	x		
Small Group Discussion		x	x			x			
Programmed Instruction		x	x	x					
Chapter Problems			x			x		x	
Study Help	x	x		x				x	
Teacher Lecture	x	x	x						
Demonstration Exercise	x						x		
Review Film	x								
Teacher Conference		x	x				x	x	

NOTE: x indicates the criteria used to select learning activities for individual guides.

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[43] Paden, op. cit., p. 23.

Measurement of Three Varieties of Self-Reliance[44] instrument as being self-directed were encouraged by the guide to continue to function in this manner, while those students who had not developed the self-concept necessary to work independently were directed into small groups. The students in this latter group usually required more teacher attention and guidance than the self-dependent students.

In addition to the suggested sequence of activities, each guide included: (1) diagnostic pretest instructions, (2) behavioral objectives for the unit, (3) a suggested time schedule, (4) a statement concerning the personal responsibilities associated with individualized instruction, (5) the student's post-unit goals, and (6) directions for obtaining the post-unit test and recycling instructions if they were necessary.

The teacher immediately scored and evaluated the student's written responses to the chapter test when the test was submitted to him. This practice permitted immediate reinforcement for those students who reached the criterion established by the behavioral objectives and allowed immediate attention and diagnosis to those students who did not reach the criterion established by the objectives they had selected.

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[44] Stott, loc. cit.

Each guide had three major divisions: (1) the introduction containing the statements shown in Table 4, (2) the main body described after Table 4, (3) the evaluation section which included the statements in Table 5 (page 39).

Although modified slightly, both Tables 4 and 5 and the following list were obtained from Dr. Jon Paden's dissertation. The explanation for this utilization is that the investigator utilized the basic computer program designed by Paden for his study. Therefore, the format of the printouts of the student instructional guides for the investigator's study were very similar to that developed by Paden.

The following fifteen statements represent the structure for the body of the student guides. The statements appropriate to the individual based upon the idiographic factors mentioned previously and consistent with the content being studied were included in the guide. Appropriate statements for section one of the chapter were selected and printed followed by selected statements related to each of the remaining sections in the chapter. The following is a list of paragraphs that were available to the computer to construct a unique instructional guide for each student.

1. List the behavioral objectives for the concepts that are being studied.
2. Inform the student of an available introductory film when it is appropriate.

Table 4[45]

Statements Printed at the Beginning of
Each Instructional Guide

Statement Name	Statement Description
Greeting	Personalized welcome to the topic.
Introduction	An introductory statement about the chapter being studied.
Pacing	An explanation of how the suggested pacing is calculated.
Time	Gives the suggested number of days to complete the chapter.
Independence	Outlines in some detail the degree of independence attainable by this methodology.
Diagnostic Pretest	Instructions to take the diagnostic test for the chapter.
Behavioral Objectives	Lists all of the behavioral objectives to be mastered in the unit of study.

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[45] Paden, _op_. _cit_., p. 26.

3. Suggest to the student that he perform the laboratory exercises related to the current section when it is appropriate.
4. Suggest to the student that a write-up of the laboratory exercise is expected when it is appropriate.
5. Suggest to the student that he read the current section of the text or related materials when it is appropriate.
6. Alert the student to the supplementary audio tapes related to the current section when it is appropriate.
7. Alert the student to the supplementary single-concept film loops related to the current section when it is appropriate.
8. Identify a topic or question and suggest that a small group discussion occur.
9. Alert the student to any programmed instruction materials that are available on the current topic.
10. List the "home, desk, and lab" problems which relate to the current section and suggest specific problems to work.
11. Invite the students to visit with the teacher for extra help when it is appropriate.
12. Establish a small group lecture session and invite the student to attend.

13. Suggest a demonstration which might be completed at home or in class when it is appropriate.
14. Alert the student to review films which are available and appropriate to the section being studied.
15. Suggest a student-teacher conference if the student feels it is necessary.[46]

The experimental group students were strongly encouraged to follow the sequence that was prescribed for them. As the sections were completed, the teacher recorded this information to monitor the student's progress. The interaction between the student and teacher was based, to a large extent, upon the guide and the student's observed progress relative to it. Each student was expected to plan his work so that he would complete his unit on schedule. After the student completed the unit, he proceeded to the last section of the guide, which is explained in Table 5. Examples of the individually prescribed instructional guides for Chapters 19 and 20 appear in Appendix L.

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[46] Paden, op. cit., pp. 27-29.

Table 5[47]

Statements Printed at the End of Each Instructional Guide

Statement Name	Statement Description
Posttest	Instructs the student to take the chapter test.
Recycle	Suggests to the student that he may recycle through any topics with which he had difficulty when taking the posttest. He is encouraged to continue to the next chapter if he reached criterion.

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[47] *Ibid.*, p. 27.

Analysis of the Data

The principal research question was tested by analysis of covariance with the pretest scores serving as the covariant.

The second research question was tested by analysis of variance with the attitude test scores serving as the dependent variable.

The third research question concerning learning efficiency was tested by utilizing a one-way analysis of variance with the teaching method serving as the independent variable, and the learning efficiency ratios serving as the dependent variable.

The fourth research question concerned a frequency count of objectives successfully realized by students in each treatment group. To test this question required the utilization of the chi-square statistic.

Multiple correlation was employed to test the significance of the relationship between the criterion variable (physics achievement) and nine independent variables: (1) accumulated math-science honor points, (2-3) reading achievement and reading rate as measured by the Nelson-Denny Reading Test,[48] (4-6) educational progress in mathematics, science, and writing achievement as measured by the Sequential Test of Educational Progress,[49] (7) self-reliance as measured by Every Day Life: A Scale for the Measurement of Three Varieties of Self-Reliance,[50] and (8-9) verbal and non-verbal ability as measured by the California Test of Mental Maturity.[51] These nine independent variables were relevant to research question five.

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[48] Nelson-Denny, loc. cit.

Summary

The purpose of the study, within the limitations imposed by the length of the study, sampling procedure, content, and type of study was to develop and evaluate an instructional model which utilized the computer to produce individually prescribed instructional guides designed to account for the idiosyncratic variations among students in physics classes at the secondary level of education.

The teacher in this study taught one treatment group, referred to as the control group, using group methods and the other treatment group, referred to as the experimental group, by individualized techniques.

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[49] Buros, loc. cit.

[50] Stott, loc. cit.

[51] Sullivan, Clark, and Tiegs, loc. cit.

The investigator was responsible for collecting the idiographic data on each student, altering the computer guide program for this study, developing content objectives for Chapters 19 and 20, developing the objective planning sheets for Chapters 19 and 20, developing a program to print a chapter test based upon the cooperatively selected objective, establishing a test item bank with items for each cognitive level and each content objective, producing and duplicating audio tapes and printed materials, and developing and evaluating the pretest-posttest achievement instrument.

One of the most challenging of the preceding tasks was that of developing the objective planning sheets for Chapters 19 and 20. The format of each sheet, as previously mentioned, consisted of the general content objective, six cognitive alternatives categorized according to Bloom's cognitive taxonomy,[52] and three proficiency levels. The general content objectives were determined from previous teaching experience and suggested topics in the P. S. S. C. Teacher's Guide.[53] After the general content objectives were determined, six specific cognitive objectives were generated for each general objective. These alternatives were produced to allow the student some choice in developing his behavioral objectives for the unit of study. To provide additional flexibility and choice, three proficiency levels (100% mastery, 80% mastery, or 60% mastery) were added to the objective planning sheet. The objective created from the student's cognitive objective choice and the selected level of proficiency satisfied Mager's three criteria[54] for a behavioral objective.

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[52] Bloom, loc. cit.

[53] P. S. S. C., Physics Teacher's Resource Book and Guide, op. cit., Chapters 19 and 20.

The experiment phase of the study began after a twelve week orientation period during which time the students in the experimental group learned to function in an open climate environment. The treatment phase, commencing after the orientation period, was conducted for five weeks and provided pedagogical structure to Chapters 19 and 20 in P.S.S.C. physics.[55]

The instructional model of this study was tested for variations in achievement, attitude, and learning efficiency against the values of the control group who received instruction based upon a different model of teaching.

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[54] Robert F. Mager, Preparing Instructional Objectives (Palo Alto: Fearon Publishers, 1962), p. 2.

[55] P.S.S.C., *op. cit.*, Chapters 19 and 20.

Chapter 2 reports upon the research relevant to theories of learning, models of teaching, and individualized instruction.

Chapter 3 gives a detailed description of the data and the statistical procedures which were employed to produce the findings and conclusions which are reported in Chapter 4.

Chapter 2

REVIEW OF LITERATURE

The topic of individualized instruction has well established roots in the history of American education. The concern for the capabilities of the individual student and the associated tendency to place upon him considerable responsibility for his own intellectual development are characteristic of the English philosopher Locke, from whom our beliefs in individual liberty and responsibility are said to be derived. American heroes, personified by Abraham Lincoln, are held in high esteem for their personal traits of self-determination and self-reliance.

Educational philosophy has also emphasized individual responsibility for learning. Gagne noted writers at the turn of the century reflected the concern for the individual and his learning: "What the individual child needs to learn is whatever he has not already learned, and that which will fill his needs and contribute to the meeting of his life goals."[1] In recent times, an increased emphasis on the uniqueness and importance of the individual learner in the educational system has been noticed. For example, for the past twenty years the number of schools employing ability grouping, remedial classes, multi-track curricula, unit assignments, course enrichment, and guidance services have steadily increased. These practices were, for the most part, innovations and techniques developed to do something about the heterogeneity of the student population in the public schools across the United States.[2] A more recent innovation is the nongraded school whose characteristics at both the elementary and secondary level have been described in administrative texts and journals. An essential feature of the nongraded school is its dependence on the motivation, interest, and curiosity of the individual student and the ensuing delegation of responsibility for learning upon the student.[3]

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[1] Robert Gagne, "Learning Research and Its Implications for Independent Learning," The Theory and Nature of Independent Learning, Gerald T. Gleason (ed.) (Scranton: International Book Company, 1967), p. 15.

Another modern technique that has given impetus to the movement toward individualized instructional practices is programmed instruction. The learner proceeds through a sequence of learning steps at his own rate and reinforcement of response is immediate. Teaching machines have been developed to administer the program, but these devices are not essential. Skinner's operant conditioning theory serves as the theoretical base for programmed instruction. Skinner's writings also indicate that the most efficient control of human learning requires instrumental aid via programmed instruction.[4]

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[2] Lester W. Anderson and Lauren A. Van Dyke, Secondary School Administration (Boston: Houghton Mifflin Company, 1963), pp. 61-62.

[3] B. Frank Brown, "The Nongraded High School," Readings in Secondary Education, Weldon Beckner and Wayne Dumas (eds.) (Scranton: International Textbook Company, 1968), pp. 297-298.

LEARNING THEORIES

If learning is individualized, and the responsibility for learning is placed on the individual student, will this educational arrangement take into account research evidence about learning as a human activity, or will it ignore known data and establish new parameters? To answer this question, it is necessary to consider different models of the learning process. Models of the learning process take various forms. Occasionally they are clearly stated as theories; sometimes they are represented in diagrams; often they are not stated at all but merely implied. However, it is these models that must be considered when one attempts to evaluate the practical implications of learning research.[5] The two models described here are the Single Stage and the Multi-Stage models of learning.

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[4] Morris L. Bigge, Learning Theories for Teachers (New York: Harper & Row, 1964), p. 134.

Single-Stage Model of Learning

The Single-Stage model of learning developed the connection between a stimulus and a response. Early champions of this model were Pavlov, Watson, and Guthrie. Watson and Guthrie were called contiguity theorists because they avoided making reference to the reinforcing effects of rewards.[6] In their systems, learning was assumed to depend only on the contiguity of stimulus and response. In taking this position, Watson and Guthrie stood in contrast to another group of behavioristic theorists referred to as reinforcement theorists. Thorndike, Skinner, and Miller were classified in this latter group. The reinforcement theorists stated that the reinforcing effect of rewards was essential in the analysis of learning.[7]

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[5] Gagne, op. cit., p. 17.

[6] Ernest R. Hilgard, Theories of Learning (New York: Appleton-Century-Crofts, 1956), pp. 48-53.

[7] Winfred F. Hill, Learning: A Survey of Psychological Interpretations (San Francisco: Chandler Publishing Company, 1963), pp. 51-89.

The following is a brief account of the necessary conditions in the learning process described by the Single-Stage model. Careful planning and execution on the part of the teacher was necessary to insure that stimuli were presented in a sequence which insured proper time relations with the response. Reinforcement was immediate, and repetition of the situation was accounted for in the learning sequence. The learner or recipient of this learning program had to be cognizant of his surroundings and capable of processing the stimulation provided so that a response could be made.[8]

Multi-Stage Model of Learning

The Multi-Stage model of learning stated that all learning could not be accounted for by a connection between a stimulus and a response. Early work in this area was conducted by Hunter, Hull, and later by Spence.[9] Hull's Reinforcement Theory initially consisted of four stages and later was revised to include five stages.

The Multi-Stage model of learning produced a shift of emphasis from the two ends of the learning event to the middle. The process in the middle became known as mediation. Mediation is an inferred process in which external stimuli are coded by the learner's nervous system before being functionally connected with responses. The coding may depend to some extent upon inherited factors in the nervous system, but more important to educators is the fact that coding depends upon previous learning which has put the nervous system in its present condition.[10]

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[8] Gagne, op. cit., p. 19.

[9] Hill, op. cit., pp. 157-158.

The importance of previously acquired mediational processes for a given task of current learning has been emphasized in the studies of Gagne and his associates.

> The learning of increasingly complex mathematical tasks was shown to depend upon the previous mastery of other contributory mathematical principles, in a hierarchical fashion. Evidence presented by these authors shows that the learning of any given task is successful to a high degree for those students who have mastered specific prerequisite tasks, and highly unsuccessful in those students who have not mastered the subordinate tasks. The learning of any given subject matter, it is suggested, can be shown to depend upon the prior learning of other subject matter. Thus, the latter, previously learned capabilities, act as mediators of the learning of the new task.[11]

The mediation process which codes the stimulus is generated by the learner. Thus, the recurring theme of the individual learner being the master of his educational fate has some justification when learning is explained by the Multi-Stage model.

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[10] Gagne, op. cit., p. 25.

[11] Ibid., p. 26.

MODELS OF TEACHING

The preceding section on learning theories conveys briefly some of the psychologists' work on learning. The theories of learning represent a large and active field of concern. Books by Hilgard,[12] Hill,[13] and Bigge[14] are examples of efforts to record, compare, criticize and apply learning theories in education. In contrast to this large array of printed materials on learning theories is the disparingly meager supply of publications on teaching theories. One explanation for the apathy toward teaching theories stems from the idea that learning is a more general phenomenon, as psychologists conceive it, than is teaching.[15] According to Gage:

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[12] Hilgard, op. cit.

[13] Hill, op. cit.

[14] Bigge, op. cit.

[15] John P. De Cecco, The Psychology of Learning and Instruction (Englewood Cliffs: Prentice-Hall, 1968), p. 8.

> Learning as a subject of scientific study embraces more than what goes on in schools. . . . learning is considered to occur in all areas of life, not merely those in the formal educational setting. The effects of propaganda, psychotherapy, child-rearing, social groups, and teachers are seen as explicable in terms of learning, and hence of theories of learning.[16]

In contrast to this, discourse on teaching is usually restricted to school situations.[17]

Another explanation for the relative neglect of teaching theories may be that they are unnecessary on strictly logical grounds. If adequate theories of learning are known, then the teacher should act upon that theory without employing a separate theory of teaching. Gage stated:

> The teacher, if he is to engender learning, must of necessity do what the theory of learning stipulates as necessary for learning to occur.[18]

This conception of a learning theory's applicability to teaching may explain the lack of concern by psychologists with theories of teaching.[19]

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[16] N. L. Gage, "Paradigms for Research on Teaching," *Handbook of Research on Teaching*, N. L. Gage (ed.) (Chicago: Rand McNally, 1963), p. 133.

[17] *Ibid.*

[18] *Ibid.*

[19] *Ibid.*

In presenting a case for the need of theories of teaching, consider additional remarks of Gage.

> Too much of educational psychology makes the teacher infer what he needs to do from what he is told about learners and learning. Theories of teaching would make explicit how teachers behave, why they behave as they do, and with what effects.[20]

From Gage's remarks we may conclude that theories of teaching need to develop on an equal basis with theories of learning.

Gage,[21] De Cecco,[22] Bruner,[23] and Stolurow[24] have established criteria for constructing a theory of teaching. Bruner lists four major features for a theory of instruction.

> 1. Predisposition—. . . specify the experiences which most effectively implant in the individual a predisposition toward learning.

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[20] Ibid.

[21] Ibid.

[22] De Cecco, op. cit., p. 73.

[23] Jerome S. Bruner, Toward a Theory of Instruction (Cambridge: Belkap Press, 1966), pp. 40-41.

[24] Lawrence M. Stolurow, "Some Factors in the Design of Systems for Computer-Assisted Instruction," Computer-Assisted Instruction: A Book of Readings, Richard Atkinson (ed.) (New York: Academic Press, 1969), p. 68.

> 2. Structure—. . . specify the ways in which a body of knowledge should be structured for most efficient learning.
>
> 3. Sequence—. . . specify the most effective sequence in which to present the materials to be learned.
>
> 4. Reinforcement—. . . specify the nature and pacing of rewards and punishments in the process of learning and teaching.[25]

General remarks from De Cecco infer that a teaching theory should apply to all teachers, all students, all subject matter, and all situations both in and out of school in which teaching may occur.[26]

With these varied criteria in mind, let us review a number of teaching models that have been developed during the past decade. Asahel D. Woodruff developed a three-fold concept of teaching in his book, Basic Concepts of Teaching. His model was a triad consisting of objective-learning experience-receptiveness for learning. The simplicity of the model was inherent in Woodruff's plan because the model was designed to give beginning teachers a guide in constructing lessons.[27] Woodruff's model considered all of

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[25] Bruner, loc. cit.

[26] De Cecco, op. cit., p. 7.

[27] Asahel D. Woodruff, Basic Concepts of Teaching (San Francisco: Chandler Publishing Company, 1961), pp. 29-31.

Bruner's specific criteria but reinforcement was difficult to place within the scheme.

Another model, called the Social Interaction model championed by Flanders, has received much attention in recent years. Flanders' model classified the statements of students and teachers recorded from classroom verbal interaction into ten categories. The ten categories were grouped under Teacher Talk or Student Talk sections with Teacher Talk again divided into the Direct Influence and the Indirect Influence cells. When the teacher's verbal responses were placed in the Direct Influence cells, the teacher was restricting the student's freedom of participation. On the other hand, when the teacher's responses were coded in the Indirect Influence cells, student participation and responses were enhanced. Flanders theorized that learning cycles occurred within the classroom with the teacher's role changing from Direct to Indirect Influence. The role of the teacher coupled with the cycle affected two aspects of learning: the student's dependence and achievement. In assessing the interaction model in light of Bruner's criteria for model construction, we find major deficiencies. Sequence and structure were neglected at the outset because objectives and the learning program were not clearly defined. Reinforcement was accounted for to some extent due to the interaction of the students and teacher.[28]

Carroll developed a model in the sixties that was based upon the concept of time. An assumption of this model was that a student would attain an instructional objective if he spent the necessary time to learn the task. Carroll's model consisted of five major components:

(a) aptitude—learning time to reach criterion under optimal learning conditions.

(b) perseverance—amount of time the student is willing to spend in reaching the criteria.

(c) ability to comprehend instruction—general intelligence of student.

(d) opportunity to learn—amount of time allowed for learning.

(e) quality of instruction—degree of organization of instruction.[29]

Carroll's model did not specify behavioral objectives, although the implication was present that they were the criteria that were being sought. Special emphasis of this model would be upon Bruner's criteria of predisposition and structure.[30]

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[28] Edmund J. Amidon and Ned A. Flanders, The Role of the Teacher in the Classroom (Minneapolis: Association for Productive Teaching, Inc., 1967).

[29] John B. Carroll, "Research on Teaching Foreign Languages," Handbook of Research on Teaching, N. L. Gage (ed.) (Chicago: Rand McNally, 1963), p. 134.

In 1962 Glaser developed a four component teaching model. The four components of his model were: "(a) analyzing the characteristics of subject matter competence, (b) diagnosing preinstructional behavior, (c) carrying out the instructional process, and (d) measuring learning outcomes."[31] The component, (a) analyzing the characteristics of subject matter competence, was concerned with the selection of instructional objectives. One responsibility in the selection of objectives was to identify the kind of behavior desired so that appropriate learning programs would be developed which facilitated the learning of that kind of behavior. Another responsible factor was the distinction between the behavioral state and the process of attaining that behavioral state. A third factor considered in selecting objectives was the significance of transfer and concept formation to specific subject matter.[32]

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[30] De Cecco, op. cit., pp. 15-16.

[31] Robert Glaser (offprint), The Design of Instruction, Chapter IX of Sixty-fifth Yearbook of the National Society for the Study of Education, Part II (Chicago: National Society for the Study of Education, 1966), p. 217.

[32] Ibid., pp. 217-223.

The second component, (b) diagnosing preinstructional behavior, was an assessment of the learner's entering behavior. Among preinstructional variables affecting the course of achievement were: extent of mastery of response sought, extent of prerequisite knowledge, extent of development of individual's learning set for response, and discriminatory ability.

Since these variables were identified as factors affecting achievement, the next step was to develop techniques for the accommodation of these variables in the instructional program.[33]

The third component, (c) carrying out the instructional process, was initiated once the objectives were selected and the entering behavior of the student was described. At this point, a precise instructional process could be implemented. In subject matter learning, the instructional process could be defined as a means of arranging the student's environment to expedite learning. Glaser inferred that there were at least three subprocesses involved:

> (a) setting up new forms of student behavior, such as new speaking patterns . . .

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[33] *Ibid.*, pp. 223-226.

(b) setting up new kinds of stimulus control, for example learning to read after having learned to speak, so that the already learned response of making speech sounds is attached to particular visual symbols; and

(c) maintaining the behavior of the student.[34]

If it was assumed that learning involved the subprocesses just mentioned, attention could be directed to some conditions such as: sequencing, stimulus and response factors, practice, and response contingencies which influence these processes. These conditions were specifically stated for the student's "transitional behavior," the activity of the student enroute to the criteria of the terminal objectives.[35]

The fourth component, (d) measuring learning outcomes, was concerned with the performance assessment of the student and his learning program. If this assessment indicated the student had failed to reach the criteria stated in the objectives, one or all of the preceding components may have required adjustment and revision. One inherent difficulty, however, was the validity of the assessment instrument. It seems possible that tests which were constructed to be sensitive to individual student differences could not be the same kinds of tests that were sensitive to the difference produced by different instructional conditions. Therefore, careful judgment had to be exercised in assessing the value of the learning program.[36]

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[34] Ibid., p. 227.

[35] Ibid., pp. 229-239.

Glaser's model took all of Bruner's criteria for teaching theory construction into account and the simplicity of the design was perhaps one reason for its applicability to teaching.

The models developed by Woodruff, Flanders, Carroll, and Glaser had one assumption in common: the process of teaching would be conducted by teachers. With the advent of computers into the field of education, this assumption was no longer absolute. Smallwood developed a mathematical model for computer-based instructional systems in 1962. This model was followed by another computer-based model proposed by Stolurow and Davis in 1965. Their model, referred to as the Idiographic Programming Model, could be used to control instruction in a dynamic interactive process. This interactive process was accomplished by (a) presenting information and questions in frames, (b) presenting multiple forms of evaluative feedback, (c) processing responses discriminately, and (d) recording student performance data. At each point where a decision had to be made concerning these operations, a teaching rule was activated to make the decision. These rules were stored in the computer and automatically applied in the selection of every block of material for each student as he responded.[37]

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[36] Ibid., pp. 238-240.

The Idiographic Programming Model divided the decision process into three different stages: pretutorial, tutorial, and administrative. The pretutorial stage constituted the initial decisions made to develop the first teaching strategy to use with the student. Once the process commenced, the strategy was monitored to determine whether revisions were needed. The tutorial stage in this model was cybernetic because the student's responses determined the nature and sequence of the program he received.[38]

Stolurow established a rigorous set of standards for instructional systems designed for the individual learner in the article, "Some Factors in the Design of Systems for Computer-Assisted Instruction."

> In an instructional system that uses the idiographic model of programming it should be possible to use any or all of the following characteristics of the student in a contingency statement or teaching rule: (a) aptitude scores; (b) personality test scores; (c) reading rate; (d) knowledge about prerequisite

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[37] Stolurow, op. cit., p. 72.

[38] Ibid.

> information; (e) immediate and delayed retention span; (f) reinforcement; and (g) preferences. It should also be possible to base decisions, at least in part, on: (a) the response to the last frame; (b) the responses to a set of other related frames; and (c) the response latencies.[39]

Obviously, such a system would be computer-based. In a later section of the same article, Stolurow stated,

> It is assumed that the purpose of an adaptive instructional system is to optimize instruction by using the most pertinent and useful information. . . . it must: (a) raise the performance level of as many different types of students as possible; (b) in as short a time as possible; and (c) at as small a cost as possible.[40]

In order to do this, an instructional system should present only the material needed by each student to reach the criteria established by the terminal objectives. Second, the system must be capable of organizing materials. Third, the presentation rate of the materials or pacing should be controlled by the instructional system.[41]

INDIVIDUALIZED INSTRUCTION

The evolvement of a model of teaching that considers individual differences was the subject of a preceding section.

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[39] *Ibid.*, p. 73.

[40] *Ibid.*, p. 75.

[41] *Ibid.*

Obviously, Stolurow's model achieved the ultimate in catering to the unique needs and abilities of individual students. Unfortunately, at the present stage of development, limited materials have been produced to test the adequacy of the model.

Hedges presented a strong case for individualizing instruction in describing the variability of students in the area of academic achievement of the same chronological age. This variability was indicated by what he termed the two-thirds rule.

> This rule is an easy and realistic way to perceive the tremendous variability in achievement with which the elementary, junior high, and senior high teacher is confronted. In effect, this rule says that there will usually be a range in achievement that is equal to two-thirds of the age of the typical student in a given class.[42]

Applying this rule, first grade children range about four years in reading or arithmetic achievement, while ninth grade students range about ten years in achievement in these areas.

Later in the same article, Hedges developed additional justification for individualizing instruction by referring to students' varying reaction time, need to move, intra-individual differences, and destruction of self-esteem. These differences would likely be placed in the non-content areas of behavior, but they certainly affect the student's performance in the cognitive or content domain.[43]

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[42] William Hedges, "A Rationale for Individualizing Instruction," Hedges Letters, Letter #2 (Chicago: Science Research Associates, Inc., October 23, 1967).

Carroll has predicted that the study of instructional methods and individual differences will be most difficult and frustrating. Truth of this prediction can be verified to some degree by noting the inconsistent and inconclusive research findings now available on this topic.[44] Even the correlation of intelligence to instructional method is subject to question. Stolurow explained an observed difference in achievement between groups of different intelligence in terms of the efficiency of instruction for the two groups.[45]

Tallmadge and Shearer reported after conducting the last of a series of three experiments to determine the relationships between learning styles, training methods, and the nature of learning experiences, significant interaction between the three variables. However, the first two experiments failed to show significant interaction.[46]

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[43] Ibid.

[44] John B. Carroll, "Instructional Methods and Individual Differences," Learning and Individual Differences, Robert Gagne (ed.) (Columbus: Charles E. Merrill Books, Inc., 1967), p. 41.

[45] De Cecco, op. cit., p. 64.

Novak reported studies using methods which allowed for individual differences by altering the instructional techniques indicated little or no significant variations in achievement when compared with conventionally taught classes. However, he inferred the critical issue in individualizing instruction was to match the teaching input to the individual's cognitive structure.[47] Proceeding from this point, Novak stated,

> The solution, as proposed by Ausubel, is to provide relevant subsumers when they are not available or to make more discriminable those that are by offering an "advanced organizer." The feature of individualized instruction is to offer material particularly suited to the learner through the use of organizers.[48]

On the positive side of the issue, Summerlin reported from a pilot study involving C. A. I. in chemistry at the secondary level a substantial decrease in learning time with no adverse effects in attitudes or achievement.[49]

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[46] G. Kasten Tallmadge and James W. Shearer, "Relationships Among Learning Styles, Instructional Methods, and the Nature of Learning Experiences," Journal of Educational Psychology, 60:222, June, 1969.

[47] Joseph D. Novak, Donald G. Ring, and Pinchas Tamir, "Interpretations of Research Findings in Terms of Ausubel's Theory and Implications for Science Education," (unpublished paper at the time of acquisition, 1969), p. 13.

[48] Ibid.

Other studies by Paden,[50] Peterson,[51] Williams,[52] and Shavelson and Munger,[53] in applied research on individualized instruction, have reported significant gains in achievement compared with conventional group instruction. The results of these studies are encouraging in view of the prognostications of noted educators mentioned earlier.

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[49] Lee Summerlin, "Student Attitudes Toward Computer-Assisted Instruction in Chemistry," Science Teacher, 38:31, April, 1971.

[50] Jon S. Paden, "An Experimental Study of Individualized Instruction in High School Physics Using the Computer to Prescribe Activities as a Function of Selected Idiographic Factors" (unpublished Doctoral dissertation, University of Missouri-Columbia, 1970), pp. 81-82.

[51] Richard Smith Peterson, "Development and Evaluation of an Individualized Learning Unit in Science for the Junior High School" (unpublished Doctoral dissertation, University of Utah, 1970), p. 103. Microfilm.

[52] William N. Williams, "An Experimental Investigation of Individualized Instruction in the Teaching of Quantitative Physical Science" (unpublished Doctoral dissertation, Duke University, 1969), pp. 64-65. Microfilm.

[53] R. J. Shavelson and M. R. Munger, "Individualized Instruction: A Systems Approach," Journal of Educational Research, 63:263-6, February, 1970.

To lend credence to the preceding two statements, brief reviews of the research of Paden, Peterson, Williams, and Shavelson and Munger on individualized instruction are in order.

Paden conducted a study which utilized the computer to produce individually prescribed study guides designed to accommodate differentiated learning styles of high school physics students. Two teachers were assigned to two classes each of fifteen students. Each teacher taught one class traditionally and one class using individualized instruction techniques. Paden found that the achievement levels of the experimental groups taught by a computer-assisted individually prescribed approach, whose computer program logic was keyed to student interests and desired learning modes, were significantly higher than those of group-taught classes.[54]

Peterson's study involved the design of an investigation to analyze change in the acquisition of physical science subject matter. The subject matter was organized into a conceptual framework between junior high school students (grades 7 to 9) in individualized classes and in lecture-demonstration classes. Unlike Paden's study, Peterson collected data from fifty-eight classes, thirty-one of which were individualized while the remaining twenty-seven classes were taught by the lecture-demonstration method. The fifty-eight classes involved in this study were taught by twenty-three different teachers. Peterson found that students in individualized classes earned significantly higher gain scores on an achievement test than those in lecture-demonstration centered classes.[55]

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[54] Paden, loc. cit.

Williams conducted an individualized versus group instruction study which involved 192 ninth grade physical science students. In this study, each of the two treatment groups and the reference group consisted of sixty-four students. Williams identified the independent variable as the teaching method (individualized or group) and his dependent variables were: group achievement scores, retention, and the time required to complete the activities. Williams found that achievement on semester examinations, standardized tests, and semester grades were enhanced when instruction was provided by the individualized mode. Based upon differences of pre- and post-administrations of an achievement test, Williams concluded that retention was enhanced when instruction was provided by the individualized mode. The investigator also concluded that with the same subject matter, students in the individualized mode completed more activities than students involved with group instruction.[56]

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[55] Peterson, op. cit., pp. 100-104.

Shavelson and Munger conducted a study with ninety-six high school students to test the relative effectiveness of an individualized secondary science instruction system with a traditional self-contained classroom approach. The students were randomly assigned into four groups of twenty-four. The three treatment groups were made up of biology students, while the control group (non-treatment group) was composed of geology students. Again, the independent variable was the mode of instruction (individualized, large group) and the dependent variables were: achievement and temporal span to complete the content unit. The investigators found that performance on the achievement instrument was significantly higher for those students involved with individualized study. In addition, the temporal span necessary to complete the content unit was found to be significantly less for the groups that used the individualized instruction system.[57]

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[56] Williams, op. cit., pp. 62-67.

[57] Shavelson and Munger, loc. cit.

The four preceding studies involved subject matter in the natural sciences with junior high or senior high school students comprising the treatment group populations. Each study sought to determine the effect on content achievement when the individualized mode of instruction was used. Of the studies cited, only Paden's study utilized a computer-produced instructional guide in the treatment. The state of reported research on individualized instruction is expanding rapidly. However, research on the utilization of computer-managed instructional systems in the individualized mode is still very limited.

It is the investigator's hope that this study will add to the base of research on computer-managed instructional systems and provide evidence of trends and identify possible pitfalls in such a system.

Chapter 3

TREATMENT OF THE DATA

STATISTICAL HYPOTHESES

The following statistical hypotheses have been developed from the research questions stated in Chapter 1.

Principal Statistical Hypothesis

1. H0: There will be no significant difference between the achievement scores in P. S. S. C. physics obtained by the experimental group compared to the achievement scores obtained by the control group.

H1: P. S. S. C. physics students will achieve more by utilizing the teaching model developed for this study than by utilizing the traditional model.

H0: $Se^2 = Sc^2$

H1: $Se^2 > Sc^2$

Secondary Statistical Hypotheses

2. H0: There will be no significant difference between the attitudes of the students in the experimental group toward the course of physics and the attitude scores of the students of the

control group as measured by the Purdue Master Attitude Scale for Measuring Attitude Toward Any School Subject.[1]

H1: Students participating in the experimental group will exhibit higher scores, thus more positive attitudes, toward the physics course than will students of the control group.

H0: $Se^2 = Sc^2$

H1: $Se^2 > Sc^2$

3. H0: There will be no significant difference between learning efficiency of students in the experimental group and the learning efficiency of students in the control group.

H1: The learning efficiency indices of the experimental group will be greater than the learning efficiency indices of the control group.

H0: $Se^2 = Sc^2$

H1: $Se^2 > Sc^2$

4. H0: The number of behavioral objectives successfully mastered by the students of both treatment groups will not differ significantly.

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[1] H. H. Remmers, "A Scale to Measure Attitude Toward Any School Subject," Purdue Research Foundation, 1960.

H1: The number of behavioral objectives successfully mastered by students of both treatment groups will differ significantly.

H0: $Ne = Nc$

H1: $Ne \neq Nc$

5. H0: Achievement in the experimental group (individualized instruction) is not related to:

(a) the accumulated math-science honor points since grade nine,

(b) the reading comprehension of the students,

(c) the reading rate of the students,

(d) the self-reliance of the students,

(e) the educational progress of the students in science, mathematics, and writing achievement as measured by the STEP instrument,[2]

(f) the verbal and non-verbal ability as measured by the CTMM (short-form) instrument.[3]

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[2] Oscar Buros, "Sequential Tests of Educational Progress," *The Sixth Mental Measurements Yearbook* (Highland Park: Gryphon Press, 1965), pp. 100-109.

[3] Elizabeth T. Sullivan, Willis W. Clark, and Ernest W. Tiegs, "California Short-Form Test of Mental Maturity," *The Sixth Mental Measurements Yearbook* (Highland Park: Gryphon Press, 1965), p. 693.

This chapter includes a description of the instruments, data, methodology of collecting the data, and the analysis of the data pertinent to the stated statistical hypotheses. The critical values will be identified and stated for the various tests of significance.

SOURCES OF DATA

Student Records

In the initial chapter and Appendix I of this paper, a description and accompanying diagram of the logic structure and decision making scheme of the computer program was presented to explain how the computer developed an instructional guide unique for each student in the experimental group. The decisions made by the computer were based upon nine types of idiographic data. (These data appear in Appendix A.) Student achievement as measured by the accumulated honor points in science and mathematics since grade nine was one of the types of data. This information was obtained from the students' cumulative records. The honor points were calculated by multiplying the numerical equivalent of the grade received by the credits assigned to the course. The letter grades were assigned numerical equivalents based upon a four point scale.

Additional data obtained from students' cumulative records included educational progress in science, mathematics, and writing achievement as measured by the Sequential Test of Educational Progress (STEP) instrument.[4] (These data also appear in Appendix A.)

Teacher Administered Instruments

The teacher and investigator collected additional idiographic data and dependent variable data from various tests that were administered to the treatment groups during the orientation and experiment phases of the study. The ensuing material briefly describes each instrument that was used to generate the data.

The Every-Day Life Scale, developed by Stott, measured three varieties of self-reliance. Stott identified independence in personal matters, resourcefulness in group situations, and personal responsibility as the most clearly defined varieties of self-reliance. Stott developed a questionnaire consisting of sixty-nine items to measure these qualities. The reliability of this instrument was determined by utilization of the Spearman-Brown formula. The values for the reliability ranged from .84 to .94. The validity of the scores as indicators of the varieties measured was insured by the methods of item selection employed. The data collected on self-reliance by utilization of this instrument appear in Appendix A. The self-reliance scores were considered as one of the criteria used to determine the student's learning program.[5]

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[4] Buros, loc. cit.

The California Test of Mental Maturity - Short Form, developed by Clark and Tiegs, was administered to each student to obtain verbal and non-verbal ability values which served as additional criteria in determining the student's learning program. The total score of each student obtained from this instrument was used to calculate the learning efficiency ratio which was stated in statistical hypothesis 3. The reported reliability value determined by the Kuder-Richardson formula 20 for this instrument was .93.[6] The data obtained from this test appear in Appendix A.

The Nelson-Denny Reading Test - Form A, developed by Nelson and Denny and revised by Brown, was administered to each student enrolled in physics to obtain idiographic data concerning each student's reading ability. These data were used as another criteria to develop the learning program for the students in the experimental group. This instrument was designed to provide information on a student's vocabulary, comprehension, and reading rate. The raw scores of this test for each student appear in Appendix A. The procedure used for determining the validity and reliability was described in the manual for this instrument. The reported reliabilities ranged from .81 to .93.[7]

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[5] Stott's Inventory: A Manual of Directions and Norms (Beverly Hills: Sheridan Psychological Services, Inc., 1941).

[6] Willis W. Clark and Ernest W. Tiegs, Examiner's Manual, California Test of Mental Maturity (Monterey: California Test Bureau, 1964).

The *Purdue Master Attitude Scale for Measuring Attitude Toward Any School Subject - Form B*, edited by Remmers, was administered to each student in both treatment groups. Form B was administered at the conclusion of the experiment phase. The data obtained from this form were used to evaluate statistical hypothesis 2. The title conveys the function of the instrument. The procedures used to determine the validity and reliability of this form of the instrument are explained in the manual. The reliability values given in the manual range from .71 to .92. The data obtained from this test appear in Appendix B.[8]

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[7] M. J. Nelson and E. C. Denny, *Examiner's Manual: The Nelson-Denny Reading Test*, revised by James I. Brown (Boston: Houghton-Mifflin Company, 1960), p. 26.

[8] A. H. Remmers, *Manual for the Purdue Master Attitude Scales* (West Lafayette: University Book Store, 1960).

The Physics Achievement Instrument, developed by the investigator and critiqued by the teacher, encompassed the content provided in chapters 19 and 20 of the P. S. S. C. physics course.[9] This instrument was administered at the beginning of the experiment phase to both treatment groups for the covariant data, and again at the conclusion of the experiment phase for the criterion variable for statistical hypotheses 1, 3, and 5. The instrument consisted of forty multiple choice questions with five alternate answers. The content validity of the instrument was assured by synthesizing the questions from examples and problems found in the text and teacher's guide of P. S. S. C.[10] Additional emphasis on content validity was guaranteed since each question applied to one or more of the content objectives of chapters 19 and 20 of the P. S. S. C. text.[11]

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[9] Physical Science Study Committee, Physics (New York: D. C. Heath, 1964), Chapters 19 and 20.

[10] Physical Science Study Committee, Physics Teacher's Resource Book and Guide, 2nd edition (New York: D. C. Heath, 1966), Part III.

[11] P. S. S. C., Physics, loc. cit.

The internal consistency estimate of reliability determined on this instrument was found to be .836. Kerlinger[12] and Guilford[13] provided guidelines in constructing a homogeneous instrument that maximized the reliability without sacrificing the validity of the instrument. These guidelines included:

a. items of moderate difficulty yield the greatest variance;

b. the greater the item intercorrelation, the greater the internal consistency of the instrument;

c. reliability will be higher when the items are nearly equal in difficulty;[14]

d. multiple choice questions with numerous alternatives are more reliable than true-false questions;[15]

e. the reliability is usually enhanced by using many items.[16]

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[12] Fred Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart, and Winston, 1964).

[13] J. P. Guilford, Fundamental Statistics in Education and Psychology (New York: McGraw-Hill, 1965).

[14] *Ibid.*, pp. 455-456.

[15] *Ibid.*, p. 449.

[16] *Ibid.*, p. 465.

These suggestions were utilized in constructing the instrument. This instrument was field-tested on thirty-nine high school physics students enrolled at Hickman High School during the spring term of the 1970-71 school year. An item analysis was performed on the data obtained from this trial utilizing the SWIAP library program of the University of Missouri's Computer Center.[17] This program provided raw score listings by class rank and alphabet, T-scores, frequency distribution of scores, difficulty index of each test item, item variance, group mean, standard deviation, Kuder-Richardson formula 20 reliability value, and standard error of measurement value. The difficulty index value and the item variance value enabled the investigator to evaluate the test with respect to specific aspects of test construction referenced to Guilford in the preceding paragraph.[18] The Kuder-Richardson formula 20 equation provided the internal consistency reliability estimate ($r\pi$) of the instrument, and the standard error of measurement was interpreted to represent the probable extent of error in test scores.

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[17] David Gill, *SWIAP: Item Analysis of Examination Scores* (Computer program on accessible file at the University of Missouri-Columbia Computer Center.).

[18] Guilford, *op. cit.*, pp. 455-456.

The statistics cited in the preceding paragraph concerning the analysis of the Physics Achievement Instrument appear in Appendix C accompanying a copy of the instrument. Minor changes in some of the problem formats and related figures were made after considering the field-administered test's item analysis statistics.

ANALYSIS OF THE DATA

Student Achievement in Physics

The testing of the principal statistical hypothesis was accomplished by applying the one-way analysis of covariance statistic.[19] This statistical procedure was used because random assignment of students to the treatment groups was not feasible. The use of statistical controls through covariance was defensible since the technique of random assignment was not feasible under the conditions of the experimental setting. Lana stated:

> Given a constant N, the use of a pretest will often increase the precision of measurement by controlling for differences within subgroups. In addition, should there be a "failure" of randomization, comparison of the subgroups' pretest means will tell us so.[20]

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[19] Quinn McNemar, Psychological Statistics (New York: John Wiley and Sons, 1969), pp. 413-426.

[20] Robert E. Lana, "Pretest Sensitization," Artifacts in Behavioral Research, Robert Rosenthal, Ralph L. Rosnow, editors (New York: Academic Press, 1969), p. 122.

The mean and standard deviation for the pre-treatment administration of the achievement test was 15.96 and 5.40, respectively, for the experimental treatment group. The post-treatment administration of the same instrument to the experimental treatment group yielded a mean of 24.17, and a standard deviation of 5.22. The experimental treatment group had a sample size of 24 students. The adjusted mean for the experimental treatment group, determined by using the pretest score as the covariant, was 23.88.

For the control treatment group, the mean and standard deviation for the pre-treatment administration of the achievement test was 14.85 and 3.65, respectively. The post-treatment administration of the same instrument to the control treatment group yielded a mean of 23.30, and a standard deviation of 4.45. The control treatment group had a sample size of 20 students. The adjusted mean for the control treatment group, determined by using the pretest score as the covariant, was 23.64.

Table 6 lists the means, standard deviations, and group size of each treatment group for the pretest and posttest data.

The criterion variable, as stated in hypothesis 1, was the achievement score on the posttest. The pretest achievement score served as the covariant with the treatment group classification serving as the independent variable. The corresponding pretest and posttest scores appear in Appendix D on each student in both

Table 6

Means, Standard Deviations, and Adjusted Means of Group Scores on the Physics Achievement Instrument

	Experimental Group	Control Group
Pretest	N = 24	N = 20
	$\overline{X}$ = 15.96	$\overline{X}$ = 14.85
	SD = 5.40	SD = 3.65
Posttest	$\overline{X}$ = 24.17	$\overline{X}$ = 23.30
	SD = 5.22	SD = 4.45
	Adj. $\overline{X}$ = 23.882	Adj. $\overline{X}$ = 23.640

treatment groups. Covariance was used to remove the effect of the differences which existed in the pretest scores. The mean square values of 0. 63 for between groups and 16. 99 for within groups yielded an F ratio of 0. 04. At the . 05 level, an F value of 4. 08 was necessary to reject the null hypothesis. Consequently, the null was accepted for hypothesis 1. Table 7 contains the summary of the statistical analysis of student achievement in physics as measured by an achievement test.

Table 7

Analysis of Covariance of Student Achievement in
Chapters 19-20 of P. S. S. C. Physics

Source	df	ss	ms	F	p
Between groups	1. 00	0. 63	0. 63	0. 04	<P. 05
Within groups	41. 00	694. 46	16. 99		
Total	42. 00	697. 09			

Student Attitudes Toward Physics

The attitudes of students toward the course of physics constituted the subject of the second statistical hypothesis. This hypothesis stated that no significant difference in attitudes of students toward physics would occur due to the utilization of different teaching models. The one-way analysis of variance was the statistical procedure used to test this hypothesis. This procedure was justified by again referring to the experimental design of this study. Since students were not randomly assigned to the treatment groups, the use of statistical controls appeared to be the appropriate solution to account for group differences. However, this alternative was rejected due to the necessity of knowing the authorship of the responses on each attitudinal questionnaire. The investigator felt that since the questionnaires could not be completed anonymously, the student would possibly have reservations about responding as feelings dictated. Therefore, the analysis of variance was used to test the significance of hypothesis 2.

Another concern in establishing a statistical procedure to test hypothesis 2 was the scale classification of the data. Questions have often been raised concerning the utilization of parametric statistical procedures to analyze attitudinal data, because attitude questionnaires characteristically yield nominal scale or ordinal scale data. The *Purdue Master Attitude Scale* was developed as an equal-appearing interval scale.[21] This type of questionnaire approaches interval scale data when reliability of the instrument is high and justifiably allows the resulting data to be treated with parametric statistics.

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[21] Kerlinger, *op. cit.*, p. 485.

The score on the attitude scale served as the dependent variable, while the treatment group classification was the independent variable. The attitude scores for individual students in each treatment group appear in Appendix B.

The mean and standard deviation recorded for the experimental treatment group on the attitude questionnaire were 6.98 and 1.55, respectively. The mean and standard deviation recorded for the control treatment group on the attitude questionnaire were 7.51 and 0.91. All 24 of the students in the experimental treatment group completed the questionnaire, while 19 students of the control treatment group completed the questionnaire. The variances or mean square values of 3.00 for between groups, and 1.72 for within groups yielded an F value of 1.75. At the .05 level, an F value of 4.08 was necessary to reject the null hypothesis. Consequently, the null was accepted for hypothesis 2. Table 8 contains a summary of the statistical analysis of student attitudes toward the course of physics.

Learning Efficiency

Learning efficiency was the subject of the third statistical hypothesis. This hypothesis stated that learning efficiency was not affected by the model of teaching that was utilized in the treatment

Table 8

Analysis of Student Attitudes Toward the Course of Physics by Treatment Groups

A. Group Means

	Experimental	Control
N	24.	19.
Mean	6.98	7.51
SD	1.55	0.91

B. Analysis of Variance

Source	df	ss	ms	F	p
Between groups	1.00	3.00	3.00	1.75	<P.05
Within groups	41.00	70.34	1.72		
Total	42.00	73.34			

phase. One-way analysis of variance was used to test the significance of statistical hypothesis 3. The independent variable for this hypothesis was the treatment group classification. The dependent variable was the learning efficiency ratio for each student. The student performance (T score on posttest), student ability (total score of CTMM), and student skill (STEP science score) values which served as the raw data for calculating the learning efficiency ratios appear in Appendix E along with a listing of the learning efficiency ratios.

The sample size of both treatment groups was influenced in this test by the availability of STEP science scores on each student. The necessary data to calculate learning efficiency ratios were obtained from 23 members of the experimental treatment group and 16 members of the control treatment group. The mean and standard deviation recorded for the experimental treatment group on the learning efficiency ratios were 0. 73 and 0. 25. The mean and standard deviation recorded for the control treatment group on the learning efficiency ratios were 0. 66 and 0. 22. The mean square values of 0. 05 for between groups and 0. 06 for within groups yielded an F value of 0. 78. At the . 05 level, an F value of 4. 11 was necessary to reject the null hypothesis. Consequently, the null was accepted for hypothesis 3. The summary of the analysis of the learning efficiency ratios by treatment groups is presented in Table 9.

Table 9

Analysis of Learning Efficiency Ratios by Treatment Groups

A. Group Means

	Experimental	Control
N	23.	16.
Mean	0.73	0.66
SD	0.25	0.22

B. Analysis of Variance

Source	df	ss	ms	F	p
Between groups	1.00	0.05	0.05	0.78	<P.05
Within groups	37.00	2.15	0.06		
Total	38.00	2.19			

Objective Attainment

The number of objectives successfully mastered by students of both treatment groups was the concern of statistical hypothesis 4. The data for this hypothesis were produced from the computer-generated tests administered to each student at the end of chapters 19 and 20. The decision regarding attainment or mastery of each behavioral objective was made by the teacher, based upon the student's performance on the chapter test. If the student reached criterion as stated by the objective, the teacher recorded this achievement in his record book. Students in the control group had only one opportunity to demonstrate mastery of the stated objectives. However, the teacher had the option of conferring with each student separately. Students in the experimental group had to master each objective before proceeding to the next chapter. The question related to this hypothesis was not concerned with the cognitive level attained or the time involved in mastering the concept, but rather the number of objectives actually mastered within the period of this study. This information provided evidence to support the premise that self-pacing enhanced the amount of material learned by the student. Tabulation of the behavioral objectives mastered and not mastered for each student in both treatment groups appears in Appendix F. A 2 x 2 chi-square statistic with one degree of freedom was used to test the significance of the number of objectives achieved by students of the two treatment groups. Of the 264 objectives assigned to students in the experimental treatment group, 191 were successfully achieved and 73 were not achieved. In the control treatment group, 220 objectives were assigned to the students, 137 of which were achieved and 83 which were not achieved. The resulting chi-square value was determined to be 5.57. At the .05 level, a chi-square value of 3.84 was necessary to reject the null hypothesis. Consequently, the null was rejected for hypothesis 4. Table 10 contains a summary of the statistical analysis related to hypothesis 4.

Multiple Correlation

A multiple correlation value and nine partial correlation values were utilized to test the null form of hypothesis 5. The multiple correlation value was determined to be 0.776; the corresponding F value was 2.186. At the .05 level, an F value of 2.72 was necessary to reject the null hypothesis. Consequently, the null was accepted for the overall combination of variables with physics achievement.

Partial correlation values were calculated to enable the investigator to determine the relation between each of the independent variables and the achievement scores on the post-treatment test. The resulting partial correlation values were: accumulated math-science honor points, -0.186; reading score, -0.191; reading

Table 10

Chi-Square Value and Frequency of Objectives Mastered and Not Mastered by the Treatment Groups in Chapters 19 and 20

Group	Mastered	Not Mastered	Total Assigned
Experimental	191	73	264
Control	137	83	220
Total	328	156	484

Chi-square value = 5.57

P.05<

rate, 0.279; self-reliance, 0.094; STEP science, 0.321; STEP math, 0.496; STEP writing, -0.103; CTMM verbal, 0.301; CTMM non-verbal, 0.101. At the .05 level, an r value of 0.344 was necessary to indicate a significant relationship. The partial correlation value resulting from the STEP math and physics achievement combination was sufficiently large to indicate a significant relationship. In addition, Fisher t values for each partial correlation were determined. The only significant t value resulted from the STEP math achievement score correlation. Table 11 contains a summary of the partial correlation values, t tests, and beta weights associated with each independent variable and the physics achievement scores for students in the experimental treatment group.

The data reported in the preceding pages in Tables 6 through 11 were collected to support or reject the statistical hypotheses stated at the beginning of this chapter. The discussion of these data in regard to related research is the subject of the section entitled "Results of Data Analysis," in Chapter 4. In addition, Chapter 4 enumerates the conclusions and implications of this research for education.

Table 11

The Relationship Between Physics Achievement and Idiographic Factors Used to Develop Learning Program: Shown by Multiple Correlation

Variable Name	Experimental Group r	t for regression	Beta Weight
Accumulated Honor Points	-.186	-.684	-.139
Reading Score	-.191	-.702	-.079
Reading Rate	.279	1.046	.016
Self-Reliance Score	.094	.340	.011
STEP			
Science	.321	1.22	.265
Mathematics	.496	2.06*	.588
Writing	-.103	-.374	-.089
CTMM			
Verbal	.301	1.139	.391
Non-verbal	.101	.364	.091
R	0.776		
F	2.186		

The critical value for F (9, 13) at the .05 level = 2.70

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*Significant t based upon an alpha level of .05.

Chapter 4

FINDINGS AND CONCLUSIONS

This chapter contains (a) a brief overview of the design of the study, (b) the results of the data analysis and the relation of the findings with empirical evidence of related research studies, (c) the investigator's conclusions of the teaching model used in the experiment phase, (d) implications for education, and (e) suggestions for further research.

OVERVIEW

The purpose of this study was to develop and evaluate an instructional model which utilized the computer to produce individually prescribed instructional guides to account for the idiosyncratic variations among students in physics classes at the secondary school level.

One instructor was responsible for directing the learning activities in physics to three scheduled classes. Of these, two were selected by random techniques to serve as the treatment groups, e.g., individualized and traditional. An orientation phase of twelve weeks duration was utilized to enable the students in the experimental group to become accustomed to techniques unique to the individualized instructional model. The students were oriented to the practices of selecting behavioral objectives from objective planning sheets, using computer-produced instructional guides, and accepting individual responsibility for learning. At the conclusion of the orientation phase, the treatment phase commenced with an achievement pretest in physics. The concepts, principles, and examples of two chapters in the P. S. S. C. text served as the principal content source during the treatment phase for both treatment groups. Chapter tests developed by utilizing each student's objectives were administered at the conclusion of each chapter to both groups. The conclusion of the treatment phase was signified by the administration of an attitude questionnaire and the post-achievement test. The temporal span of the treatment phase was five weeks.

The criterion variable for statistical hypotheses 1, 3, and 5 was the student's score on the physics achievement test. The dependent variable for statistical hypotheses 2 and 4 was the student's attitude score and the frequency of objectives mastered, respectively.

The independent variable for statistical hypotheses 1, 2, 3, and 4 was the type of treatment administered, while in hypothesis 5 the independent variables were identified as the nine selected idiographic factors used to generate the student study guides.

Analysis of covariance with pretest measures serving as the covariant was used to test hypothesis 1. Statistical hypotheses 2 and 3 were tested by using the analysis of variance statistic. Hypothesis 4 was evaluated with the 2 x 2 chi-square statistic, while multiple correlation was applied to the data to evaluate hypothesis 5.

RESULTS OF DATA ANALYSIS

Primary Statistical Hypothesis

The primary statistical hypothesis in the null form stated that any difference in the achievement scores comparing instruction structured by the experimental teaching model which accommodated individualized learning with instruction structured by the group instructional model would be a chance occurrence. The one-way analysis of covariance statistic, with the achievement pretest scores serving as the covariant, was used to test the null hypothesis. The mean value of the post-achievement test for the experimental treatment group was 24.17, while the standard deviation was 5.22. The adjusted mean was 23.88 for the experimental group. The descriptive statistics for the post-achievement test for the control group included a mean of 23.30, a standard deviation of 4.45, and an adjusted mean of 23.64. With such a slight difference in the adjusted mean scores for the two treatment groups, it was evident that no significant difference existed between the achievement mean scores. The F ratio for this hypothesis was determined to be 0.04, clearly below the .05 level of significance of 4.08 for an F ratio with 1,41 degrees of freedom. Therefore, the null hypothesis was accepted.

Although the mean difference was minimal and the F ratio was not significant, the experimental group did exceed the control group's performance slightly on the achievement instrument. The direction of change was consistent with the research findings of Paden,[1] Peterson,[2] and Williams.[3] Each of these investigators reported a significant difference in the achievement of treatment groups utilizing individualized techniques over those using group instructional practices. Conversely, Novak reported that studies using methods which allowed for individual differences by altering the instructional techniques demonstrated little or no significant variations in achievement when compared with traditionally taught classes.[4] The results of the test of significance on hypothesis 1 apparently support Novak's position, although the direction of change supports the rationale for stating a directional hypothesis.

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[1] Jon S. Paden, "An Experimental Study of Individualized Instruction in High School Physics Using the Computer to Prescribe Activities as a Function of Selected Idiographic Factors" (unpublished Doctoral dissertation, University of Missouri-Columbia, 1970), pp. 82-83.

[2] Richard Smith Peterson, "Development and Evaluation of an Individualized Learning Unit in Science for the Junior High School" (unpublished Doctoral dissertation, University of Utah, 1970), p. 103. Microfilm.

[3] William W. Williams, "An Experimental Investigation of Individualized Instruction in the Teaching of Quantitative Physical Science" (unpublished Doctoral dissertation, Duke University, 1969), pp. 64-65. Microfilm.

Secondary Statistical Hypotheses

Attitude toward physics course. Hypothesis 2 in the null form stated that any difference in the attitudes of the students in either treatment toward the course of physics would be a chance occurrence. The one-way analysis of variance for groups of unequal N statistic was utilized to test the significance of this null hypothesis. The mean value of the attitude instrument for the experimental treatment group was 6.98, while the standard deviation was 1.55. The preceding descriptive statistics for the experimental treatment group was obtained from analyzing the data of the 24 students in the group. The descriptive statistics for the attitude instrument for the control group included a sample size of 19, a mean of 7.51, and a standard deviation of 0.91. The F ratio for this hypothesis was determined to be 1.75. This calculated value was less than the .05 level of significance value of 4.08 for an F ratio with 1, 41 degrees of freedom. Therefore, the stated null hypothesis was accepted.

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[4] Joseph D. Novak, Donald G. Ring, and Pinchas Tamir, "Interpretation of Research Findings in Terms of Ausubel's Theory and Implications for Science Education" (unpublished paper at time of acquisition, 1969), p. 13.

Although the F ratio was not significant, the direction of change of attitude toward the subject was not consistent with research findings reported by Krockover,[5] Williams,[6] and Summerlin.[7] Krockover reported that students enrolled in an individualized CBA chemistry course tended to evaluate their teacher higher than students taught by group instruction.[8] Williams reported in his study that students involved with individualized instruction felt they learned more, enjoyed class more, and made better grades when they were involved in individualized instruction.[9] In an article on student attitudes with respect to CAI in chemistry, Summerlin reported that students involved with this mode of individualized instruction expressed opinions that CAI was superior to traditional instruction, but would prefer traditional instruction due to the personality factor of the teacher.[10] All of the studies cited inferred that students were affected by individualized techniques. However, none of these studies cited specifically made reference to student attitudes toward the course itself.

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[5] Gerald Howard Krockover, "A Comparison of Learning Outcomes in CBA Chemistry When Group and Individualized Instruction Techniques are Employed" (unpublished Doctoral dissertation, University of Iowa, 1970), p. 74. Microfilm.

[6] Williams, loc. cit.

[7] Lee Summerlin, "Student Attitudes Toward Computer-Assisted Instruction in Chemistry," Science Teacher, 38:31 (April, 1971), pp. 30-32.

[8] Krockover, loc. cit.

[9] Williams, loc. cit.

The direction of change on the test of significance on hypothesis 2 does suggest that students accustomed to instruction directed to the group are affected by individualized techniques when cast into the individualized mode of instruction. Though the difference of attitude scores for the two groups was not significant according to the results of hypothesis 2, the F ratio was large enough to suggest that some relationship between student attitudes toward the course itself and the mode of instruction may exist.

Learning efficiency. Hypothesis 3 asserted that there would be no difference in the learning efficiency values of students in the experimental treatment group compared with the learning efficiency values of students in the control treatment group. The one-way analysis of variance for groups of unequal N statistic was utilized to test the significance of this null hypothesis. The mean value of the learning efficiency ratios for the experimental group was 0.73 while the standard deviation was 0.25. The preceding descriptive statistics for the experimental treatment group were obtained from analyzing the data of 23 students in the group. The descriptive statistics for the control group included a sample size of 16, a mean of 0.66, and a standard deviation of 0.22. The F ratio for this hypothesis was determined to be 0.78. This calculated value was less than the .05 level of significance value of 4.11 for an F ratio with 1, 37 degrees of freedom. Therefore, the stated null hypothesis was accepted.

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[10] Summerlin, loc. cit.

Although the calculated F ratio was not significant, the resulting direction of change was consistent with Stead's research findings on the factors at the secondary school level that affect learning efficiency. Stead reported that high learning efficiency areas utilized activities and action processes in the instructional program, and stressed individualized instruction. Stead also stated that high learning efficiency areas tended to be nonacademic in content.[11]

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[11] John Henry Stead, "Some Factors in the Secondary School Curriculum Which Affect Student Learning Efficiency" (unpublished Doctoral dissertation, University of Southern California, 1969), p. 181. Microfilm.

The experimental design of the study reported in the dissertation allowed the investigator to consider only one of the three factors (individualized instruction) as an independent variable. The nonacademic content factor was held constant because both treatment groups utilized the same content material. Activities and action instructional processes were controlled because both groups were directed to conduct the same laboratory exercises. With this in mind, the direction of change observed in testing this hypothesis reflected the effect of individualized instruction upon learning efficiency ratio values and, therefore, reinforced Stead's research in this area.

Objective attainment. Hypothesis 4 in the null form stated that any difference in the number of behavioral objectives successfully mastered by students of both treatment groups would be a chance occurrence. A chi-square statistic was calculated from the values in a fourfold table established to classify the treatment groups and the objectives successfully mastered. Cell A of the fourfold table was designated to contain the total number of objectives successfully mastered by the experimental treatment group during the treatment phase of the study. The frequency value for cell A was found to be 191. Cell B of the fourfold table was designated to contain the total number of objectives not mastered by the experimental treatment group during the treatment phase of the study. The frequency value for cell B was found to be 73. Cell C of the fourfold table was designated to contain the total number of objectives mastered by the control treatment group during the treatment phase of the study. The frequency value for cell C was found to be 137. Cell D of the fourfold table was designated to contain the total number of objectives not mastered by the control treatment group. The frequency value for cell D was found to be 83. The total number of objectives for the experimental treatment group was 264, while the total number of objectives for the control group was 220. The total number of objectives mastered by both treatment groups was 328, while the total number of objectives not mastered by both groups was 156. The chi-square value calculated from the cell values of the fourfold table was found to be 5.57. This calculated value was found to be greater than the .05 level of significance value of 3.84 for a chi-square value with 1 degree of freedom. Therefore, a significant difference was found to occur and the null hypothesis was rejected.

Efforts to determine similar research findings concerning the relationship of objectives mastered to the instructional mode utilized met with little success. All of the studies previously cited in this study which involved individualized instruction elected not to consider the measurement of individual attainment of objectives as a variable for statistical analysis. Therefore, the investigator stated the alternate hypothesis as a two-tailed test.

Correlation of idiosyncratic variables to achievement. Hypothesis 5 stated that achievement in the experimental group would not be related to the nine components of idiosyncratic data collected on each student. Partial correlation values and their corresponding t values, the multiple correlation value and the corresponding analysis of variance value were determined to test the null hypothesis. Partial correlation values and the corresponding t test values were determined between each idiosyncratic variable and the post-achievement test scores.

The partial correlation value indicating the relationship between student achievement in physics and the idiosyncratic variable, STEP science, was determined to be 0.321. The corresponding t value for this correlation value was found to be 1.22. This calculated value was less than the .05 level of significance value of 1.76 for a t test with 14 degrees of freedom. Therefore, the null hypothesis was accepted for this combination of variables.

The partial correlation value for the relationship between student achievement in physics and STEP mathematics was determined to be 0.496. The t value for this correlation value was found to be 2.06. This calculated value was greater than the .05 level of significance value of 1.76, therefore, the null hypothesis was rejected for this combination of variables.

The relationship between student achievement in physics and the idiosyncratic variable, STEP writing, was determined to be -0.103. The corresponding t value for this partial correlation value was found to be -0.374. This calculated value was less than the .05 level of significance value. Therefore, the null hypothesis was accepted for this combination of variables.

The partial correlation value indicating the relationship between student achievement in physics and the variable, Science-Math Honor Points, was determined to be -0.186. The t value for this correlation value was found to be -0.684. This calculated value was less than the .05 level of significance value. Consequently, the null hypothesis was accepted for this combination of variables.

The value indicating the relationship between student achievement in physics and the idiosyncratic variable, Self-Reliance, was determined to be 0.094. The corresponding t value for this correlation value was found to be 0.340. This value was less than the .05 level of significance value of 1.76 for a t test with 14 degrees of freedom. Therefore, the null hypothesis was accepted for this combination of variables.

The partial correlation value between student achievement in physics and CTMM verbal ability was determined to be 0.301.

The t value for this correlation value was found to be 1. 139. This value was found not to be significant, therefore, the null hypothesis was accepted for this combination of variables.

The value for the partial correlation between student achievement in physics and the idiosyncratic variable, CTMM nonverbal ability, was determined to be 0. 101. The corresponding t value for this correlation value was found to be 0. 364. This calculated value was less than the . 05 level of significance value of 1. 76 for a t test with 14 degrees of freedom. Therefore, the null hypothesis was accepted for this combination of variables.

The partial correlation value of -0. 191 was determined for the relationship between student achievement in physics and the idiosyncratic variable, Reading score. The corresponding t value was found to be -0. 702. Since this calculated value did not exceed the significant value of 1. 76, the null hypothesis was accepted for this combination of variables.

The partial correlation between student achievement in physics and Reading rate was determined to be 0. 279. The t value for this correlation value was found to be 1. 046. This calculated value was less than the . 05 level of significance value of 1. 76 for a t test with 14 degrees of freedom. Consequently, the null hypothesis was accepted for this combination of variables.

The multiple correlation value for the nine idiosyncratic variables with physics achievement was determined to be 0.776. The corresponding F ratio for the multiple correlation was found to be 2.186. This calculated value was less than the .05 level of significance value of 2.72 for an F ratio with 9, 13 degrees of freedom. Therefore, the null hypothesis was accepted for the overall combination of variables with physics achievement.

With the exception of the three negative partial correlation values of STEP writing, Science-Math Honor Points, and Reading scores with physics achievement, the idiosyncratic variables did exhibit some degree of positive partial correlation. Product moment correlation values were also calculated between each idiosyncratic variable and physics achievement. Each of the nine idiosyncratic variables exhibited a positive correlation with physics achievement when this statistic was used. In fact, STEP science with a product moment correlation value of 0.446, STEP math with a product moment correlation value of 0.612, and CTMM verbal ability with a product moment correlation value of 0.514 all exhibited a significant correlation at the .05 level of significance.

A number of noted educators regard the relationship between idiosyncratic variables and student achievement as an important factor in developing learning programs for students.

Gagne has stated that learning is an individual act and depends extensively upon the past experience of the learner.[12] The implication here is that knowledge of the student's background will enable the teacher to structure a better learning program for the student. Stolurow has specifically listed (a) aptitude scores, (b) personality test scores, (c) reading rate, (d) knowledge of prerequisite information, (e) reinforcement, and (f) preferences as characteristics that need to be taken into account in developing instructional sequences for students.[13] Glaser has developed the need for information concerning the student's background in "diagnosing preinstructional behavior," the second step of his model of teaching.[14] Each of these sources suggested the need to explore the relationship between the student's profile developed from past experiences and student achievement.

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[12] Robert M. Gagne, "Learning Research and Its Implications for Independent Learning," The Theory and Nature of Independent Learning, Gerald T. Gleason (ed.) (Scranton: International Book Company, 1967), pp. 27-28, 30.

[13] Lawrence M. Stolurow, "Some Factors in the Design of Systems for Computer-Assisted Instruction," Computer-Assisted Instruction: A Book of Readings, Richard Atkinson (ed.) (New York: Academic Press, 1969), p. 73.

[14] Robert Glaser (offprint), The Design of Instruction, Chapter IX of Sixty-Fifth Yearbook of the National Society for the Study of Education, Part II (Chicago: National Society for the Study of Education, 1966), pp. 223-226.

Paden reported a significant correlation between STEP science and physics achievement and STEP math and physics achievement in his individualized treatment groups.[15] This empirical evidence reinforces the significant partial correlation value the investigator found between STEP math and physics achievement in the experimental treatment group. The STEP science-physics achievement partial correlation value found by the investigator to be not significant was, nevertheless, larger than all other variable correlations with physics achievement.

The comprehensive statements cited, and the empirical evidence referred to, are consistent with the findings of the investigator regarding hypothesis 5.

CONCLUSIONS

The basic purpose of this study was to develop and evaluate an instructional model which utilized the computer to produce individually prescribed instructional guides to account for the idiosyncratic variations among students in physics classes at the secondary school level. To the degree that it is possible to generalize from the analysis of the collected data from this study, the stated purpose has been achieved to the extent expressed by the ensuing conclusions.

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[15] Paden, op. cit., p. 74.

1. The achievement level of individual high school students enrolled in physics, as measured by an achievement test designed to evaluate groups of students enrolled in secondary school physics, is not significantly increased by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.
2. The achievement level of high school students of physics, as indicated by the number of objectives mastered, can be significantly increased by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.
3. The learning efficiency, as defined in this study, of high school students of physics is not significantly increased by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.
4. The attitudes toward the course of physics expressed by high school physics students who have previously

received group instruction do not change significantly by utilizing an individualized teaching model which has a decision structure based upon academic abilities and self-reliance.

IMPLICATIONS FOR EDUCATION

The conclusions reported in the previous section were based upon a limited sample. Not only was the number of students in the study small, the selection process used to assign students to the respective treatment groups was not accomplished by random techniques. Other factors limiting the generalization of these conclusions include the considerations that only one teacher and one school were involved in the study. The subject matter was limited to the content of one elective course which traditionally has been considered to be rather selective in enrollment.

Since it is quite possible that greater achievement differences than those observed by this study might be found by using the teaching model which accommodates individually prescribed instruction in different situations, extrapolation of these conclusions to other samples, teachers, or courses should be done with discretion. Individually prescribed instruction that establishes behavioral expectations or performance levels to be achieved by the student before proceeding to a new instructional unit is inappropriately evaluated by a standardized achievement test. The rationale for this assertion is based on the idea that an achievement test assumes a uniform performance level for the entire population taking the examination. The uniformity of achievement which is being measured by the group-administered test fails to take into account the varied levels of performance strived toward by those students using the individualized approach. Conversely, students pursuing a group instructional program strive toward mastering a common set of performance levels. This concept of uniformity corresponds with the assumption underlying the construction of an achievement test. Individual scores on an achievement test are comparable if all students in the group are striving toward identical objectives with uniform criterion levels of performance. However, for each learner involved with individually prescribed instruction, the achievement test may either demand too much or too little of the student. Consequently, when the test results of an entire individualized class are averaged and compared with the test results of another treatment group instructed by group techniques, the results usually reflect no significant difference in group scores. What has actually been reflected is the inability to measure possible differences in achievement due to the utilization of an instrument which is more congruent with group instructional practices than with individualized instructional practices. This observation concurs with Glaser's remarks about the difficulty of evaluating students in the individualized mode.[16]

Conclusion 3 states that the learning efficiency of a student defined as the ratio, (student achievement)^2/ability x skill, is not significantly increased by utilizing a teaching model that accommodates individualized instruction. Again, the issue of student achievement becomes important because of its appearance in the numerator of the expression used to calculate the learning efficiency ratio. The student achievement in this case is a standardized T score obtained from an achievement test. However, the ratio does reflect some idiosyncratic properties, since the ability (CTMM total score) and skill (STEP science) are unique to each individual.

Conclusion 4 indicates that the attitudes of physics students toward the course of physics was not changed significantly by employing a teaching model that accommodated individualized instruction. Some students, accustomed to group instruction, evaluated as such by written responses recorded on student critiques of the treatment phase, expressed feelings of frustration and insecurity when cast into the individualized mode of instruction. This insecurity is not unexpected, since any new situation or experience tends to make a person anxious and somewhat unsure of what is expected of him under these circumstances. This insecurity manifested itself on the attitude questionnaire, but not to the extent that a significant change in attitudes occurred.

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[16] Glaser, op. cit., pp. 238-240.

SUGGESTIONS FOR FURTHER RESEARCH

The findings of this study recorded in this chapter reveal both reinforcing and negating results when compared with other research on individualized instruction. However, the assumptions and limitations imposed upon this study give cause for exercising discretion when constructing generalizations from the conclusions.

During the temporal span of this research, certain questions and problems were identified which warrant additional study before valid generalizations can be advanced.

1. If the temporal span of the treatment were extended, would significant changes result in student attitudes toward the course and learning efficiency ratios?
2. Would an inservice training program for the instructor, focusing upon teaching methodologies for the individualized mode, affect the results of a similar study?

3. Could this teaching model be effectively utilized with physics courses other than P. S. S. C. ?
4. Can this teaching model be used effectively in subjects other than physics and with age groups other than juniors and seniors in secondary schools?
5. Are there idiographic variables that will yield better results than those utilized by this study?
6. Can the achievement gains of students in the individualized mode be more effectively measured by techniques other than group achievement tests?
7. Do objective planning sheets that categorize the cognitive levels and proficiency levels affect the level of student achievement?

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APPENDIX A

Table 12

Summary of the Independent Variables for the Experimental Group Students

Student	STEP Science	STEP Math	STEP Writing	Science Math Honor Points	Self-Reliance	CTMM Verbal Ability	CTMM Non-Verbal Ability	Reading Score	Reading Rate
1	39	28	40	33	228	47	44	54	185
2	39	32	44	39	231	56	49	76	262
3	37	35	43	56	211	42	38	72	262
4	54	43	41	46	252	51	37	73	207
5	44	44	43	46	149	52	46	80	250
6	41	44	45	49	265	51	52	93	318
7	29	33	37	44	244	42	45	62	407
8	40	32	37	47	278	47	43	51	238
9	47	40	41	50	233	44	42	62	456
10	35	38	37	41	136	43	36	68	309
11				57	140	47	42	65	359
12	47	42	48	60	304	49	37	75	318
13	39	34	47	38	206	49	43	62	298
14	35	27	49	42	290	47	44	72	390
15	35	34	40	43	233	46	50	76	207
16	40	37	40	50	237	45	38	52	250
17	45	34	42	62	278	40	44	50	226
18	43	35	39	43	254	40	51	77	298
19	39	39	46	41	258	49	48	60	349
20	31	44	41	46	242	48	49	66	262
21	48	43	47	57	274	54	46	71	287
22	36	39	54	39	224	52	48	74	349
23	38	43	55	60	272	46	50	68	349
24	33	26	26	27	264	40	42	46	436
$\overline{X}$	39.74	36.78	42.70	46.50	237.00	46.96	44.33	66.88	303.25
S	5.90	5.64	6.12	8.86	45.12	4.44	4.76	11.10	73.43

Table 13

Summary of the Independent Variables for the Control Group Students

Student	STEP Science	STEP Math	STEP Writing	Science Math Honor Points	Self-Reliance	CTMM Verbal Ability	CTMM Non-Verbal Abil.	Reading Score	Reading Rate
1	44	41	49	44	240	45	45	71	349
2	49	37	45	54	257	55	46	81	384
3	49	27	46	33	231	39	46	69	318
4				40	266	51	46	68	318
5	43	45	40	37	236	55	52	81	446
6	46	40	52	40	284	53	53	117	524
7	46	31	32	45	205	37	40	32	115
8	42	35	44	47	236	65	51	71	262
9				28	244	44	41	50	349
10		44	49	31	268	49	46	77	550
11	34	27	43	26	247	43	46	52	207
12	42	41	42	42	233	51	52	73	216
13	34	37	37	44	239	42	55	70	275
14	39	37	50	16	316	52	39	55	207
15	39	31	31	37	279	49	42	68	195
16	35	39	44	55	268	51	48	77	318
17	42	37	37	44	258	40	51	79	318
18	37	36	41	42	226	49	53	64	371
19				30	228	41	47	49	426
20	45	38	42	41	239	52	43	79	318
$\overline{X}$	41.63	36.65	42.59	38.80	250.00	48.15	47.10	69.15	323.30
S	4.91	5.21	5.95	9.42	25.01	6.78	4.69	17.15	109.83

APPENDIX B

Table 14

Summary of the Student Data on the Purdue Master Attitude Scale for Measuring Attitude Toward Any School Subject

Experimental Group Form B (posttest)	Control Group Form B (posttest)
8.50	6.50
7.90	5.50
8.10	7.70
8.30	6.50
8.50	7.70
5.75	7.90
6.50	8.30
7.70	7.70
5.75	8.10
3.10	7.90
6.50	5.75
8.50	6.50
4.70	7.90
5.50	7.70
6.25	7.90
6.90	7.70
6.00	8.50
6.50	8.50
8.70	8.50
4.70	
8.50	
7.10	
7.10	
6.50	
$\overline{X}$ = 6.98	$\overline{X}$ = 7.51
Std. = 1.55	Std. = .91

APPENDIX C

ACHIEVEMENT TEST IN PHYSICS

Directions

This is a 50 minute test containing 40 items. Do not spend too much time on any one question. If a question seems to be too difficult, make the most careful guess you can rather than waste time puzzling over it. Your score is the number of correct answers you mark.

Each question is followed by five suggested answers or completions. Select the one which is best in each case. You will mark your answer on the scan sheet accompanying the test. If you make a mistake or wish to change an answer, be sure to erase your first choice completely.

ACHIEVEMENT INSTRUMENT

Questions 1 & 2

An object sliding on a smooth surface with little friction is pulled with a constant force. In a time interval of .4 seconds the velocity changes from .1m/s to .4m/s. In a second trial, the same object is pulled with another force. In the same length of time the speed now changes from .4m/s to 1.0m/s.

1. What is the ratio of the second force to the first?

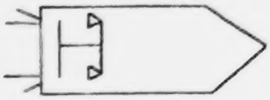
   (a) 0.2 (b) 1.5 (c) 2.0 (d) 3.0 (e) 6.0

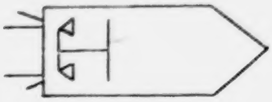
2. If the body is pulled with the second force for .8 seconds, what change in speed results?

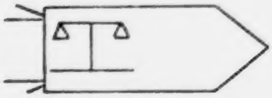
   (a) .9m/s (b) 1.2m/s (c) 2.0m/s (d) 2.5m/s (e) 3m/s

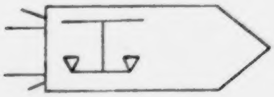
Questions 3 & 4

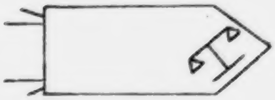
3. Suppose that an equal-arm balance was installed in Apollo 14. As the rocket was accelerated far out in space where gravitational effects due to the earth were minor, how was the balance oriented to make a mass determination of rock samples collected on the moon's surface?

(a) 

(b) 

(c) 

(d) 

(e) 

4. In making a determination of the mass of the rock samples during the acceleration of the rocket, what was being compared?

   (a) The gravitational attraction between the rocks and the weights.

   (b) The gravitational attraction of the rocket for the rocks and for the weights.

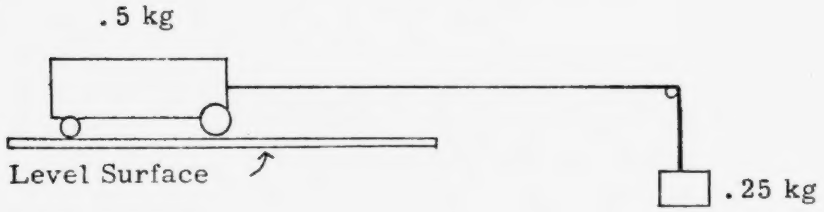
   (c) The resistance to a change in velocity of the rocks and of the weights.

   (d) The number of molecules in the rock and in the weights.

   (e) Density of the weights to the density of the rocks.

Questions 5 to 7

A .5 kg laboratory cart is connected to a mass of .25 kg by a string which runs over a small pulley, as shown in the diagram. Neglect friction. (assume $g = 10m/s^2$)



5. If the cart is held so that it cannot move, the tension in the string would be most nearly

(a) .25 nt (b) .5 nt (c) 5 nt (d) 2.5 nt (e) 7.5 nt

6. If the cart is allowed to move, its acceleration would be most nearly

(a) $.5m/s^2$ (b) $3.3m/s^2$ (c) $10m/s^2$ (d) $15m/s^2$ (e) $6.7m/s^2$

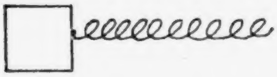
7. The tension in the string while the cart is moving could be most nearly

(a) 2.5 nt (b) 3.3 nt (c) 5 nt (d) 6.7 nt (e) 1.7 nt

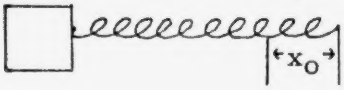
Questions 8 to 11

Several identical springs and several identical masses are used to perform dynamics experiments on a smooth surface. It is known that a single spring when extended by an amount x_o gives an acceleration a_o to a single mass.

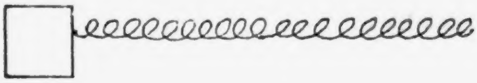
single spring: unextended



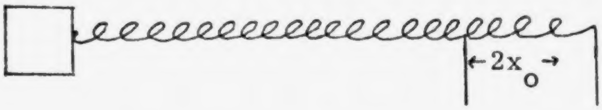
single spring: extended x_o



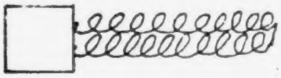
two springs connected end-to-end: unextended



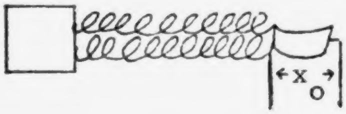
two springs connected end-to-end: extended total amount $2x_o$



two springs connected side-by-side: unextended



two springs connected side-by-side: extended x_o



8. What acceleration would be produced on a single mass by two springs connected side-by-side and extended by an amount x_o?

(a) $\frac{1}{2}a_o$

(b) a_o

(c) $2a_o$

(d) $4a_o$

(e) $1\frac{1}{2}a_o$

9. What acceleration would be produced on a single mass by two springs connected end-to-end and extended by a total amount $2x_o$?

(a) $\frac{1}{2}a_o$ (b) a_o (c) $2a_o$

(d) $4a_o$ (e) $1\frac{1}{2}a_o$

10. What acceleration would be produced on two of the masses tied together if two springs are connected end-to-end and extended by a total amount $2x_o$?

(a) $\frac{1}{2}a_o$ (b) a_o (c) $2a_o$

(d) $4a_o$ (e) $1\frac{1}{2}a_o$

11. What acceleration would be produced on two of the masses tied together if four springs are connected side-by-side and the combination is extended by an amount x_o?

(a) $\frac{1}{2}a_o$ (b) a_o (c) $2a_o$

(d) $4a_o$ (e) $1\frac{1}{2}a_o$

12. An equal-arm balance ordinarily is used to compare directly to

(a) force of attraction between each of the two bodies and the Earth.

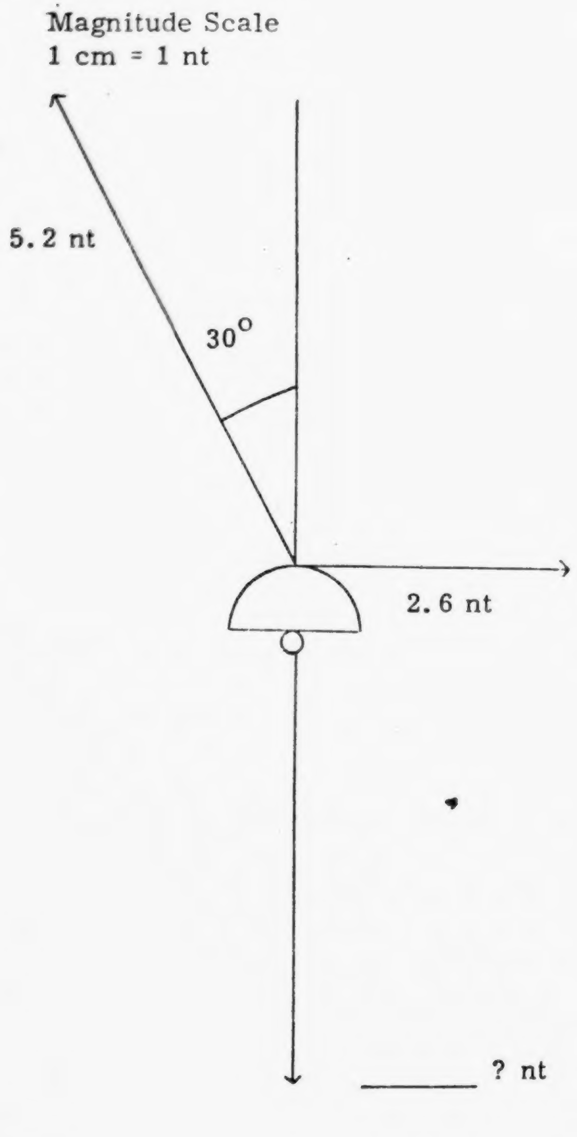
(b) gravitational attraction between two bodies.

(c) number of atoms in two bodies.

(d) density of two bodies.

(e) resistance of two bodies to acceleration.

13. A temporary light fixture for outdoor lighting is held stationary by two cords. The horizontal cord exerts a force of 2.6 nt while the cord directed 30° from the vertical exerts a magnitude of 5.2 nt. What is the weight in newtons (gravitational force) of the light fixture?


Magnitude Scale
1 cm = 1 nt
5.2 nt
30°
2.6 nt
_______ ? nt

(a) 3.5 nt

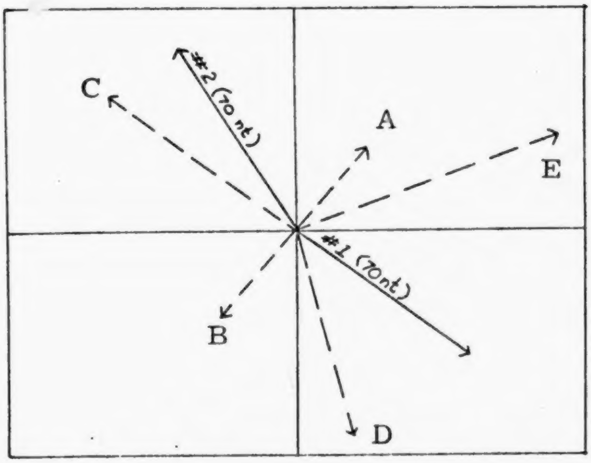
(b) 4.5 nt

(c) 6 nt

(d) 8 nt

(e) 3 nt

Questions 14 & 15



14. Which force would balance the 2 forces (vectors 1 & 2) shown in the diagram above if all 3 forces act on the same object?

(a) A (b) B (c) C (d) D (e) E

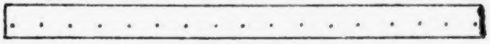
15. Which force vector represents the resultant force if force 1 and force 2 are added together?

(a) A (b) B (c) C (d) D (e) E

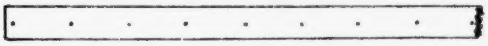
Question 16

Two laboratory carts initially at rest on a horizontal surface were pushed apart by an uncoiling spring. After the spring had uncoiled the velocities of the carts were measured directly with two identical timers. The 2 tapes shown below were obtained.

Tape for cart having mass = M1



Tape for cart having mass = M2



16. Which of the following can be correctly concluded about the masses of the carts?

    (a) $M_1 = 3\text{kg}$

    (b) $M_2 = 3\text{kg}$

    (c) M1/M2 = $\frac{1}{4}$

    (d) M1/M2 = $\frac{1}{2}$

    (e) M1/M2 = 2/1

17. A force of 3 nt gives a golf ball (m_2) an acceleration of 30 m/s^2, and a marble (m_2) an acceleration of 50 m/s^2. What approximate acceleration would the 3 nt force give to the marble and golf ball if they were fastened together?

    (a) 10 m/s^2

    (b) 13 m/s^2

    (c) 19 m/s^2

    (d) 25 m/s^2

    (e) 32 m/s^2

18. Suppose an air table puck (.1 kg) is increasing in velocity so that it travels first at 10 cm/s, at 12 cm/s at the end of the next second, 14 cm/s at the end of the third second, and so on. Which of the answers below best describes the nature of the force acting on the puck.

    (a) irregular

    (b) multiple

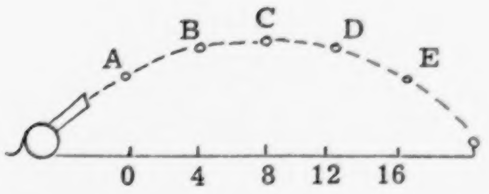
    (c) very small

    (d) large

    (e) constant

Questions 19 to 21

The figure below shows the path of a projectile fired by a toy cannon. In answering the related questions, assume frictional forces to be negligible.



19. The speed of the projectile as it leaves the miniature cannon is the same as its speed at

    (a) none of the following

    (b) B

    (c) C

    (d) D

    (e) E

20. The horizontal component of the velocity of the projectile after it leaves the muzzle of the miniature cannon is

    (a) greatest at point A

    (b) greatest at point B

    (c) greatest at point C

    (d) least at point E

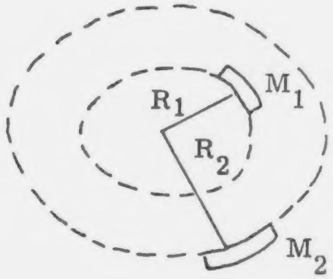
    (e) the same at all points

21. The vertical component of the velocity is zero at

    (a) A (b) B (c) C (d) D (e) E

Questions 22 & 23

Two racing cars of masses M_1 and M_2 are moving in circles of radii R_1 and R_2 as shown. Their speeds are such that they each make a complete circle in the same length of time T_1.



22. The ratio of the angular speed (measured in degrees of are per second) of the first car (M_1) to that of the second car (M_2) is

    (a) 1:1

    (b) M_1:M_2

    (c) M_2:M_1

    (d) R_1:R_2

    (e) R_2:R_1

23. The ratio of the speed measured in meters/second of the first car (M_1) to that of the second car (M_2) is

    (a) 1:1

    (b) M_1:M_2

    (c) M_2:M_1

    (d) R_1:R_2

    (e) R_2:R_1

Questions 24 to 28

A ball is thrown straight up with a velocity of 20 m/s.

24. How fast will the ball be traveling after 1.3s?

(a) 15 m/s

(b) 7 m/s

(c) 33 m/s

(d) 9 m/s

(e) 18 m/s

25. How far above the ground will it be at that time?

(a) 17.5 m

(b) 8.4 m

(c) 40 m

(d) 27.5 m

(e) 36 m

26. What is the ball's acceleration at the top of its rise?

(a) 0 m/s^2

(b) 5 m/s^2

(c) 9.8 m/s^2

(d) 15 m/s^2

(e) 7 m/s^2

27. A 1000 kg beatle (VW) is moving along at a rate of 108 km/hr (30 m/s). What braking force is necessary to stop super beatle in 75 m. ?

    (a) 1000 nt (b) 60 nt (c) 16, 000 nt (d) 6000 nt (e) 3000 nt

28. A cable exerts an upward pull of 5500 nt upon a 500 kg bale of wire. Compute the acceleration of the bale.

    (a) 1.2 m/s^2

    (b) 9.8 m/s^2

    (c) 11 m/s^2

    (d) .1 m/s^2

    (e) 6.5 m/s^2

Questions 29 & 30

A 1 kg ball is suspended from a spring. When disturbed in a vertical direction, the ball moves up and down in simple harmonic motion at a frequency of 5 cycles/second.

29. What is the period of the motion?

    (a) .2 S (b) .4 S (c) 1 S (d) 2 S (e) 4 S

30. How much did the spring stretch when the ball was first attached to its end (before the oscillatory motion was started)?

    (a) .1m (b) .15m (c) .01m (d) .05m (e) .001m

31. Which of the following expressions might be correctly used to describe the strength of a gravitational field?

    (a) 9.8 kg (b) 9.8 nt/kg (c) 9.8 kg-m/s

    (d) all of these (e) none of these

32. The moon's gravitational force is said to be approximately 1/6 of that of the earth's gravitational force. Which of the following expressions could have been used by astronaut Aldrin to describe the moon's gravitational force?

    (a) 10 nt/kg

    (b) 60 nt/kg

    (c) 6 nt/kg

    (d) 1.7 nt/kg

    (e) 4.3 nt/kg

33. At a high altitude above the earth, a falling object (mass 10 kg) is attracted to the earth with a gravitational force of 1 nt. Which of the following expressions best describes the acceleration of the object?

    (a) 10 nt/kg

    (b) 5 nt/kg

    (c) .1 nt/kg

    (d) 1 nt/kg

    (e) .01 nt/kg

34. How fast must a plane fly in a loop-the-loop of radius 1.5 km if the pilot experiences no force from either the seat or the safety belt when he is at the top of the loop? In such circumstances, the pilot is often said to be "weightless."

    (a) 1000 m/s

    (b) 700 m/s

    (c) 500 m/s

    (d) 300 m/s

    (e) 125 m/s

35. Which statement best describes a force which produces simple harmonic motion?

    (a) The force is always moving in the same direction as the object is moving.

    (b) The force is always directed along the same straight line.

    (c) The force varies in magnitude and in direction as the object moves.

    (d) Both a and b.

    (e) None of the above.

Questions 36 & 37

A golf ball is driven horizontally from an elevated tee with a velocity of 26 m/s. It strikes the fairway 2.5 seconds later.

36. How far has it fallen vertically? (approximately)

    (a) 31 m

    (b) 13 m

    (c) 47 m

    (d) 50 m

    (e) 53 m

37. How far has it traveled horizontally?

    (a) 80 m

    (b) 105 m

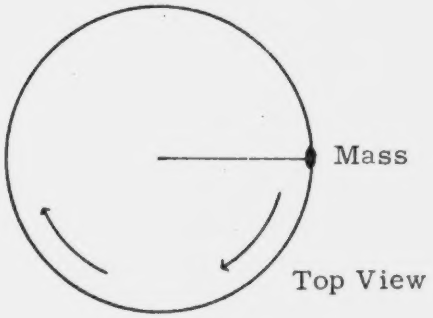
    (c) 117 m

    (d) 65 m

    (e) 200 m

Questions 38 to 40

A large circular horizontal turntable is rotating about a vertical axis at a uniform rate. A stone is held at the edge of the table as shown below. Upon being released, the stone flies off the table.



38. As seen from the center of the table, with the table as the frame of reference, the stone would then appear to

    (a) go into a circular orbit.

    (b) fly off along a tangent to the table at constant speed.

    (c) fly off along a tangent to the table at constant acceleration.

    (d) move along an extension of a radius of the table.

    (e) spiral outward.

39. As seen from a stationary point a short distance above the revolving table, with the room as the frame of reference, the stone would appear to

    (a) go into a circular orbit.

    (b) fly off along a tangent to the table at constant speed.

    (c) fly off along a tangent to the table at constant acceleration.

    (d) move along an extension of a radius of the table.

    (e) spiral outward.

40. An object with three times the mass is placed upon the turntable. The turntable continues to rotate at the same rate. Which of the following would remain unchanged from the previous trial?

I. Acceleration of the stone before release
II. Tension in the string before release of the stone
III. Path of the stone after release
IV. Speed of the stone along its path after release

(a) I & IV

(b) II & III

(c) I, III, & IV

(d) I, II, & III

(e) II, III, & IV

Table 15

Item Analysis of Data Collected During the Field Test of the Physics Achievement Instrument: Raw Scores and T Standard Scores

Student	Raw Scores	T Scores	Student	Raw Scores	T Scores
1	30	62.9	21	32	66.1
2	11	32.9	22	13	36.1
3	19	45.9	23	22	50.3
4	10	31.4	24	21	48.7
5	22	50,3	25	26	56.6
6	27	58.2	26	27	58.2
7	22	50.3	27	26	56.6
8	14	37.7	28	26	56.6
9	26	56.6	29	26	56.6
10	17	42.4	30	3	20.3
11	19	45.6	31	22	50.3
12	19	45.6	32	22	50.3
13	25	55.0	33	25	55.0
14	22	50.3	34	14	37.7
15	29	61,3	35	13	36.1
16	24	53.4	36	19	45.6
17	25	55.0	37	27	58.2
18	24	53.4	38	23	51.9
19	17	42.4	39	31	64.5
20	31	64.5			

$N = 39$

$\overline{X} = 21.82$

$S = 6.34$

Table 16

Item Analysis of Data Collected During the Field Test of the Physics Achievement Instrument: Difficulty of Items Index and Item Variance

Test Item	Item Variance	Difficulty Index	Test Item	Item Variance	Difficulty Index
1	.48	.77	21	.55	.92
2	.61	.74	22	.36	.59
3	.28	.79	23	.44	.64
4	.45	.59	24	.48	.51
5	.66	.79	25	-.06	.36
6	.11	.18	26	.41	.28
7	-.02	.03	27	.16	.41
8	.06	.87	28	.41	.26
9	.28	.33	29	.43	.69
10	.23	.33	30	.02	.05
11	.64	.74	31	.53	.72
12	.26	.72	32	.56	.90
13	.54	.56	33	.21	.64
14	.51	.87	34	.10	.05
15	.40	.64	35	.36	.18
16	.22	.51	36	.24	.33
17	.54	.64	37	.44	.67
18	.37	.85	38	.27	.33
19	.39	.67	39	.47	.38
20	.75	.79	40	.43	.46

Table 17

Item Analysis of Data Collected During the Field Test of the Physics Achievement Instrument: Kuder-Richardson Formula 20, Standard Error of Measurement

Kuder-Richardson Formula 20 Estimate of Internal Consistency Reliability	Standard Error of Measurement
.84	2.56

APPENDIX D

Table 18

Raw Scores of Students in Each Treatment Group on Physics Achievement Instrument

Student	Experimental Group		Control Group	
	Pretest	Posttest	Pretest	Posttest
1	6	17	13	23
2	12	30	18	29
3	8	16	14	23
4	22	28	14	25
5	23	27	17	27
6	26	29	16	19
7	17	17	10	
8	13	16	13	28
9	12	24	15	24
10	16	24	18	17
11	9	26	18	22
12	26	31	16	29
13	14	22	10	15
14	13	14	10	17
15	16	20	23	26
16	17	27	19	29
17	13	23	11	22
18	16	23	12	20
19	19	31	16	29
20	15	23	7	19
21	27	31	17	23
22	17	29		
23	25	26		
24	11	26		
$\overline{X}$	15.96	24.17	14.85	23.30
S	5.40	5.22	3.65	4.45

APPENDIX E

Table 19

Raw Data for Learning Efficiency Ratios

Student	Experimental Group CTMM Total	STEP Science	Posttest T-Score	Control Group CTMM Total	STEP Science	Posttest T-Score
1	91	39	36.0	90	44	48.4
2	105	39	62.8	101	49	60.8
3	80	37	34.0	85	49	48.4
4	88	54	58.7	97	--	52.5
5	98	44	56.7	107	43	56.7
6	103	41	60.8	106	46	40.2
7	87	29	36.0			
8	90	40	34.0	77	46	58.7
9	86	47	50.5	117	42	50.5
10	79	35	50.5	85	--	36.0
11	89	--	54.6	95	--	46.4
12	86	47	64.9	89	34	31.9
13	92	39	46.4	103	42	60.8
14	91	35	29.9	97	34	54.6
15	96	35	42.2	91	39	60.8
16	83	40	56.7	91	39	46.4
17	84	45	48.4	99	35	42.2
18	91	43	48.4	91	42	40.2
19	97	39	64.9	102	37	48.4
20	97	31	48.4	88	--	36.0
21	100	48	64.9	95	45	60.8
22	100	36	60.8			
23	96	38	54.6			
24	82	33	54.6			

Table 20

Learning Efficiency Ratios for Students in Each Treatment Group

Student	Experimental Group	Control Group
1	0.37	0.59
2	0.96	0.75
3	0.39	0.56
4	0.73	--
5	0.75	0.70
6	0.88	0.33
7	0.51	--
8	0.32	0.97
9	0.63	0.52
10	0.92	--
11	--	--
12	1.04	0.34
13	0.60	0.85
14	0.28	0.90
15	0.53	1.04
16	0.97	0.61
17	0.62	0.51
18	0.60	0.62
19	1.11	0.86
20	0.78	--
21	0.88	0.42
22	1.03	
23	0.82	
24	1.10	
$\overline{X}$	0.73	0.66
S	0.25	0.22

APPENDIX F

Table 21

Tabulation of Objectives Mastered and Not Mastered by Students of Both Treatment Groups

Student	Experimental Group		Control Group	
	Mastered	Not Mastered	Mastered	Not Mastered
1	8	3	9	2
2	8	3	10	1
3	9	2	5	6
4	11	0	9	2
5	8	3	8	3
6	8	3	9	2
7	8	3	6	5
8	8	3	11	0
9	6	5	4	7
10	7	4	7	4
11	10	1	7	4
12	11	0	2	9
13	7	4	1	10
14	6	5	9	2
15	7	4	8	3
16	9	2	6	5
17	4	7	9	2
18	8	3	7	4
19	8	3	7	4
20	11	0	3	8
21	7	4		
22	10	1		
23	10	1		
24	2	9		
Total	191	73	137	83

APPENDIX G

OBJECTIVE SELECTION SHEET

Name________________________________ Chapter ______________

OBJECTIVE 1
COGLEV (1) = _____, PRO (1) = _____

OBJECTIVE 2
COGLEV (2) = _____, PRO (2) = _____

OBJECTIVE 3
COGLEV (3) = _____, PRO (3) = _____

OBJECTIVE 4
COGLEV (4) = _____, PRO (4) = _____

OBJECTIVE 5
COGLEV (5) = _____, PRO (5) = _____

OBJECTIVE 6
COGLEV (6) = _____, PRO (6) = _____

OBJECTIVE 7
COGLEV (7) = _____, PRO (7) = _____

OBJECTIVE 8
COGLEV (8) = _____, PRO (8) = _____

OBJECTIVE 9
COGLEV (9) = _____, PRO (9) = _____

OBJECTIVE 10
COGLEV (10)=_____, PRO (10)= _____

Chapter 19

OBJECTIVE PLANNING SHEET

1. Content Objective. The content of this objective is related to the principle of inertia.

Cognitive Levels. I will be able to:

1. Knowledge - (1) define the inertia of an object; (2) cite examples of an object at rest and inertia of an object in motion.

2. Comprehension - generalize the effect of applied force upon the inertia of objects both at rest and in motion.

3. Application - demonstrate the inertia of an object at rest or in motion using force carts and spring scales.

4. Analysis - diagram the forces acting upon an object to initiate motion and compare this to a diagram of the forces acting upon an object in constant motion.

5. Synthesis - develop an original technique that demonstrates inertia of motion in the laboratory setting.

6. Evaluation - describe why Galileo's principle of inertia was an epic event in physics and in the evolution of thought processes.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, a written solution is required.

2. I will be expected to demonstrate 80 % mastery of this objective through explanations and problems solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 19

OBJECTIVE PLANNING SHEET

2. Content Objective. The content of this objective is related to the motion of an object when balanced and unbalanced forces act upon it.

   Cognitive Levels. I will be able to:

   1. Knowledge - (1) state the difference between kinematics and dynamics, (2) recall basic equations of motion from Chapters 5 and 6 such as $V = d/t$, $a = \Delta V / \Delta t$, $d = Vot + \frac{1}{2}at^2$, $V_f^2 = Vo^2 + 2aS$, and (3) recall the graphical interpretations from Chapter 5.

   2. Comprehension - (1) state the algebraic formulas above in statement form along with the appropriate units; (2) predict the effect of additional force upon the velocity of an object.

   3. Application - (1) operate the tape timer and cart, or air table and puck to demonstrate the effects of balanced and unbalanced forces upon the motion (i.e., velocity) of objects; (2) solve dynamics problems for one of the following variables: change in velocity, mass, duration of applied forces (the solution may be either algebraic or graphic).

   4. Analysis - determine the change in velocity and the resulting applied force acting upon the object through careful study of multi-exposure photographs of the moving object.

   5. Synthesis - (1) develop a strategy to solve complex problems which involve secondary solutions to yield data for the primary solution; (2) develop a procedure to follow to solve any kinematics problem.

6. Evaluation - explain and justify how kinematics and dynamics are alike or unlike.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.
2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.
3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 19

OBJECTIVE PLANNING SHEET

3. Content Objective. The content of this objective is related to: motion of an object when the mass of the object changes while a constant force is applied to it. (Inertial Mass)

Cognitive Levels. I will be able to:

1. Knowledge - define operationally the idea of inertial mass.
2. Comprehension - distinguish the difference between inertial and gravitational mass in the operational sense.
3. Application - (1) demonstrate the techniques to determine inertial mass,(2) apply knowledge of the inertial mass definition to solve dynamic problems given: (a) force acting upon object, (b) the acceleration of the body.
4. Analysis - outline the characteristics of inertial and gravitational mass that are similar (additive masses, units, conservation during chemical change, volume of substance) and distinguish why inertial and gravitational mass are not the same.
5. Synthesis - generate an explanation which includes the operational definitions and the characteristics of inertial mass and gravitational mass to explain the coincidental equivalence of the two masses.
6. Evaluation - justify the reason for establishing two types of mass even though they are equivalent, or develop a converse argument.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations, and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 19

OBJECTIVE PLANNING SHEET

4. Content Objective. The content of this objective is related to Newton's Law and the unit of force.

Cognitive Levels. I will be able to:

1. Knowledge - state Newton's Law of motion and name the units of force in the M. K. S. system of measurement.

2. Comprehension - explain the relationship between Newton's Law and the derivation of the units of force "newton."

3. Application - (1) predict the units of force in other measuring systems given units of length, mass, and time; (2) solve dynamic problems which involve constant forces, constant masses, with time and velocity of the object varying.

4. Analysis - (1) solve dynamics problems which include multiple forces acting upon the object in motion. The solution will require separating the effects of each force upon the object. (2) Devise an example to distinguish the type and magnitude of an applied force when the object slows down (providing a similar example was not explained in class).

5. Synthesis - solve complex dynamics problems which require an initial solution to yield the data to solve the primary problem.

6. Evaluation - appraise the usefulness and predictability of Newton's Law to describe any motion of any object.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations, and problems solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problems solutions and explanations both oral and written.

Chapter 19

OBJECTIVE PLANNING SHEET

5. Content Objective. The content of this objective is related to force vectors and Newton's Law.

   Cognitive Levels. I will be able to:

   1. Knowledge - reproduce Newton's Law in vector form. Recall the principles of vector addition and subtraction from Chapter 6.

   2. Comprehension - give examples to illustrate how (a) forces add as vectors, (b) Newton's Law applies to the vector sum of the forces acting on an object, (c) Newton's Law can be written as the relation between two vectors: net force and acceleration.

   3. Application - solve dynamics problems for the resultant force vector using vector sums and differences given the component force vectors.

   4. Analysis - diagram the forces acting upon a body utilizing vectors after observing the motion of the object and solve for the unknown component.

   5. Synthesis - devise a force vector diagram to describe all the vector components acting upon a projectile moving through the earth's atmosphere.

   6. Evaluation - compare the solution of dynamics problems using vector addition compared to algebraic solutions (consider the factors of clarity, ease of calculation, and generalizability to solve the problems).

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 20

OBJECTIVE PLANNING SHEET

1. Content Objective. The content of this objective is related to the distinction between mass and weight.

   Cognitive Levels. I will be able to:

   1. Knowledge - identify the characteristics that differentiate gravitational and inertial mass from weight (units, independence-dependence upon position).

   2. Comprehension - explain the difference between mass and weight by converting mass to weight, or by citing examples where each term may be appropriately used.

   3. Application - (1) solve force problems involving the force of gravity near the earth's surface (utilizing $g = 9.8 \frac{nt}{kg}$ in the calculations); (2) determine the weight of objects in Newtons given the gravitational mass of the object.

   4. Analysis - (1) differentiate the reasons for different gravitational constant values at different locations on the earth's surface; (2) diagram the gravitational force component on objects in motion and determine gravitational force's effect upon that motion.

   5. Synthesis - develop an explanation for the variations of gravitational force at various distances from the earth.

   6. Evaluation - appraise our societal use of the terms mass and weight and develop a rationale to explain why physics students confuse these terms.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 20

OBJECTIVE PLANNING SHEET

2. Content Objective. The content of this objective is related to vertical motion as it applies to Newton's Law.

Cognitive Levels. I will be able to:

1. Knowledge - recall the gravitational constant near the earth's surface and define terminal velocity.

2. Comprehension - convert g expressed in nt/kg to acceleration units and explain why the (-) sign appears in this expression: ($F = -mg$).

3. Application - (1) demonstrate the effect of terminal velocity upon common objects falling short distances (i. e., falling ping pong balls); (2) solve free fall problems for the final velocity, time of descent, or force acting upon object when given: gravitational mass, initial velocity, and distance object drops.

4. Analysis - compare the common characteristics of objects in free fall to objects moving over a horizontal surface with a constant force applied.

5. Synthesis - develop a sequence of steps to determine the motion which results from the action of one or more known forces, i. e., (a) determine the net force (vector sum of all the forces acting); (b) using Newton's Law, find the acceleration; (c) with the acceleration known, find the motion (velocity or displacement) by applying the kinematic equations.

6. Evaluation - describe the concept revisions necessary to extend the applicability of Newton's Law to objects in free fall.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 20

OBJECTIVE PLANNING SHEET

3. Content Objective. The content of this objective is related to Newton's Law and projectile motion.

Cognitive Levels. I will be able to:

1. Knowledge - cite examples to illustrate the independence of vertical and horizontal components of projectile motion.
2. Comprehension - distinguish the kinematic equations ($X = Vot$, $Y = \frac{1}{2}gt^2$) that describe the horizontal and vertical components of the projectile motion and defend their application.
3. Application - (1) demonstrate the independence of vertical and horizontal components of projectile motion; (2) solve problems involving projectile motion (i.e., given horizontal distance, horizontal velocity, solve for time and vertical distance object moves).
4. Analysis - (1) solve problems involving trajectories of projectiles with additional force components injected (i.e., frictional forces, air resistance); (2) diagram the gravitational force components parallel and perpendicular to the path of the object at different stages of its flight.
5. Synthesis - develop a solution of the vertical and horizontal components of projectile motion which combines the basic kinematic equations with trigonometry.
6. Evaluation - justify why the vertical and horizontal components of projectile motion are independent using Newton's Law as a basis for the explanation.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 20

OBJECTIVE PLANNING SHEET

4. Content Objective. The content of this objective is related to the application of Newton's Law to uniform circular motion.

Cognitive Levels. I will be able to:

1. Knowledge - (1) describe the effect of a constant force applied perpendicularly to the motion of an object; (2) list the equations $V = 2\pi R/t$, $a = \frac{V^2}{R}$, $F = \frac{mV^2}{R}$.
2. Comprehension - explain the meaning of each term in the equations $V = 2\pi R/t$, $a = V^2/R$, $F = mV^2/R$, and the relationship between the equations.
3. Application - (1) demonstrate circular motion and describe the forces acting upon the object as it revolves; (2) modify and apply the following equations to calculate the period and velocity of an artificial satellite. $V = 2\pi R/t$, $a = V^2/R$, $F = mV^2/R$.
4. Analysis - diagram the forces acting upon an object in circular motion and determine the relationship of the magnitude of each force to the radius of the circle and the orbital speed of the object.
5. Synthesis - derive an equation for centripetal acceleration where the acceleration is directly proportional to the radius and inversely proportional to the period.
6. Evaluation - critically describe observations of inward and outward applied forces upon objects in a circular path.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 20

OBJECTIVE PLANNING SHEET

5. Content Objective. The content of this objective is related to simple harmonic motion.

Cognitive Levels. I will be able to:

1. Knowledge - identify the characteristics and equations which describe simple harmonic motion and the period of oscillation.

2. Comprehension - relate the equations for circular motion to those of simple harmonic motion.

3. Application - use the equations ($F = -Kx$, $T = 2\pi\sqrt{\frac{m}{K}}$, $T = 2\pi\sqrt{\ell/g}$) to determine the period and displacement of a pendulum.

4. Analysis - relate the motion of an object attached to a suspended spring to the equations $F = -Kx$ and $T = 2\pi\sqrt{\frac{m}{K}}$.

5. Synthesis - compile a set of characteristics which illustrate why simple harmonic motion is more complex than circular motion.

6. Evaluation - describe analytically the relationship between $F = ma$ and $F = -Kx$.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

Chapter 20

OBJECTIVE PLANNING SHEET

6. Content Objective. The content of this objective is related to frames of reference.

Cognitive Levels. I will be able to:

1. Knowledge - identify inertial and non-inertial frames of reference.

2. Comprehension - explain the contradictory observations of motion and the acting forces upon an object from the different reference frames.

3. Application - demonstrate the technique of tracing an involute (curved path) using a straight edge and turntable and explain how this technique relates to frames of reference.

4. Analysis - diagram the forces acting upon an object in a non-inertial frame of reference and the same example from an inertial frame of reference.

5. Synthesis - develop a new reference frame to account for unseen forces (gravitational, electrical).

6. Evaluation - explain why Newton's Law is only true in a non-inertial frame of reference.

Proficiency Level.

1. I will be expected to demonstrate complete mastery of this objective either by a verbal presentation or by a written explanation. If problems are involved, written solutions are required.

2. I will be expected to demonstrate 80% mastery of this objective through explanations and problem solutions both oral and written.

3. I will be expected to demonstrate 60% mastery of this objective through problem solutions and explanations both oral and written.

APPENDIX H

TIM WEST

OBJECTIVES FOR CHAPTER 6.

YOU SHOULD BE ABLE TO:

1. DISTINGUISH BETWEEN VECTOR AND SCALAR QUANTITIES IF GIVEN A LIST OF MEASURED QUANTITIES.

2. ADD OR SUBTRACT VECTOR QUANTITIES.

3. MULTIPLY A NUMBER OR SCALAR QUANTITY BY A VECTOR QUANTITY BY GRAPHICAL METHODS.

4. RESOLVE A VECTOR INTO RECTANGULAR COMPONENTS.

5. SOLVE KINEMATICS PROBLEMS USING VECTORS.

6. SKETCH THE VELOCITY AND ACCELERATION VECTORS FOR AN OBJECT MOVING WITH UNIFORM CIRCULAR MOTION.

7. WORK PROBLEMS USING THE PYTHAGOREAN RELATIONSHIP.

8. DISCUSS THE FACT THAT THE OBSERVED MOTION OF AN OBJECT IS DEPENDENT UPON THE OBSERVER'S FRAME OF REFERENCE.

SCHEDULE FOR CHAPTER 6.

DAY	DATE	ACTIVITY
WEDNESDAY	DECEMBER 1	HAVE READ 6/1-6/3, TURN IN PROBLEMS 3,4 (NEW BOOK- 3,4)
THURSDAY	DECEMBER 2	HAVE READ 6/4-6/5. HAND IN PROBLEMS 6,10, (NEW BOOK-10, 27)
FRIDAY	DECEMBER 3	HAND IN PROBLEMS 9,12,15 (NEW BOOK 5,28,29)
MONDAY	DECEMBER 6	HAVE READ 6/6-6/7. TURN IN PROBLEMS 19,20. (NEW BOOK-14,15)
TUESDAY	DECEMBER 7	HAVE READ 6/8-6/10. TURN IN PROBLEMS 21,23 (NEW BOOK 23,24) FILM- VECTOR KINEMATICS
WEDNESDAY	DECEMBER 8	TEST OVER CHAPTER 6.

FYICS

KEVIN KREIGH

THIS IS THE ASSIGNMENT AND OBJECTIVE SHEET FOR CHAPTER 19 THE FOLLOWING OBJECTIVES WILL SERVE AS GUIDELINES FOR YOU TO USE IN STUDYING THIS CHAPTER'S CONTENT. THE TEST AT THE END OF THIS UNIT WILL BE DEVELOPED FROM THESE OBJECTIVES.

OBJECTIVES FOR CHAPTER 19

YOU SHOULD BE ABLE TO:

1. DESCRIBE HOW THE MOTION OF AN OBJECT IS AFFECTED IF:
   - A. NO UNBALANCED FORCE ACTS UPON IT.
   - B. A CONSTANT UNBALANCED FORCE ACTS UPON IT.
   - C. THE MASS OF AN OBJECT CHANGES WHILE THE UNBALANCED FORCE ACTING UPON IT REMAINS CONSTANT.
2. SOLVE DYNAMICS PROBLEMS USING THE KINEMATIC EQUATIONS DEVELOPED IN CHP. 5 AND NEWTON'S LAW AS DEVELOPED IN THIS CHAPTER. IN YOUR SOLUTION BE ABLE TO CONSIDER THE VECTOR NATURE OF NEWTON'S LAW.
3. GRAPHICALLY ADD OR SUBTRACT TWO OR MORE CONCURRENT FORCE VECTORS TO OBTAIN THE RESULTANT (OR NET) FORCE. ALSO BE ABLE TO RESOLVE FORCE VECTORS INTO COMPONENTS WITH RESPECT TO A SET OF PERPENDICULAR VECTORS.
4. DISCUSS INERTIAL AND GRAVITATIONAL MASS.
5. EXPRESS 'NEWTON' IN TERMS OF METERS, KILOGRAMS, AND SECONDS. (SUGGESTED RESEARCH: WHAT IS A DYNE AND HOW IS IT RELATED TO THE NEWTON?)

SCHEDULE FOR CHAPTER 19

DAY	DATE	ACTIVITY
WEDNESDAY	DECEMBER 8	PRETEST OVER CHAPTERS 19 AND 20.
THURSDAY	DECEMBER 9	DO LAB 20 IN CLASS.
FRIDAY	DECEMBER 10	DISCUSS AND TURN IN LAB 20. READ SECTIONS 19/1-19/3.
MONDAY	DECEMBER 13	DO LAB 21 IN CLASS.
TUESDAY	DECEMBER 14	FILM 'FORCES'. DISCUSS LAB 21 AND TURN IN WRITEUP.
WEDNESDAY	DECEMBER 15	HAVE READ 19/4-19/6. HAND IN PROBLEMS 8,9,10,11.
THURSDAY	DECEMBER 16	HAVE READ 19/7-19/8. HAND IN PROBLEMS 15,20,21.
FRIDAY	DECEMBER 17	COMPLETE THE READING OF CHAPTER 19. LAB ON FORCES

MONDAY	DECEMBER 20	TURN IN PROBLEMS 26-30,33.
TUESDAY	DECEMBER 21	QUIZ OVER CHAPTER 19.
WEDNESDAY	DECEMBER 22	FILM 'CHANGE OF SCALE' READ SECTION 5 IN CHP. 4.

FYICS

KATHY HAHN

OBJECTIVES FOR CHAPTER 20

YOU SHOULD BE ABLE TO:

1. DISCUSS THE DISTINCTION BETWEEN MASS AND WEIGHT, BY SOLVING PROBLEMS INVOLVING MASS AND WEIGHT.

2. SOLVE MOTION PROBLEMS IN WHICH A BODY IS:
   - A) IN FREE FALL. (CONSIDER SITUATIONS WITH OR WITHOUT FORCES WHICH RETARD THE MOTION)
   - B) PROJECTED ABOVE THE SURFACE OF THE EARTH.
   - C) TRAVELING WITH UNIFORM CIRCULAR MOTION.
   - D) MOVING WITH SIMPLE HARMONIC MOTION.

3. CONSIDER THE VECTOR NATURE OF EACH OF THE MOTION PROBLEMS IN OBJECTIVE 2.
4. DESCRIBE THE NET FORCE CAUSING THE MOTION IN EACH OF THE MOTION PROBLEMS IN OBJECTIVE 2 AND BE ABLE TO APPLY NEWTON'S LAW TO EACH SITUATION.
5. DISCUSS WHAT IS MEANT BY AN INERTIAL FRAME OF REFERENCE.
6. DISCUSS WHAT IS MEANT BY A FICTICIOUS FORCE.

SCHEDULE FOR CHAPTER 20.

DAY	DATE	ACTIVITY
MONDAY	JANUARY 3	HAVE READ 20/1-20/2. HAND IN PROBLEM 2.
TUESDAY	JANUARY 4	HAVE READ 20/3-20/4. HAND IN PROBLEM 8.
WEDNESDAY	JANUARY 5	WORK ON LAB 23 AND PROBLEMS 14, AND 15 DURING CLASS.
THURSDAY	JANUARY 6	FILM- 'FREE FALL', HAVE READ 20/5, TURN IN PROBLEMS 14 AND 15.
FRIDAY	JANUARY 7	DO LAB 24 IN CLASS.
MONDAY	JANUARY 10	DISCUSS LAB 24 AND TURN IT IN. SOLVE PROBLEMS 16, 17 21, 24, AND 25 IN CLASS.
TUESDAY	JANUARY 11	HAVE READ 20/6-20/7. HAND IN PROBLEMS 16,17,21,24,25.
WEDNESDAY	JANUARY 12	HAVE READ 20/8.
THURSDAY	JANUARY 13	DO LAB 25 IN CLASS.

FRIDAY	JANUARY 14	FILM- FRAMES OF REFERENCE, DISCUSS LAB 25. HAND IN PROBLEMS 31, 32.
MONDAY	JANUARY 17	SEMESTER FINAL
TUESDAY	JANUARY 18	SEMESTER FINAL
WEDNESDAY	JANUARY 19	HAVE READ 20/9-20/11. HAND IN PROBLEM 34.
THURSDAY	JANUARY 20	TEST OVER CHAPTER 20.
FRIDAY	JANUARY 21	FILM- MEASURING LARGE DISTANCES.
MONDAY	JANUARY 24	POST TEST OVER CHAPTERS 19-20.

FYICS

APPENDIX I

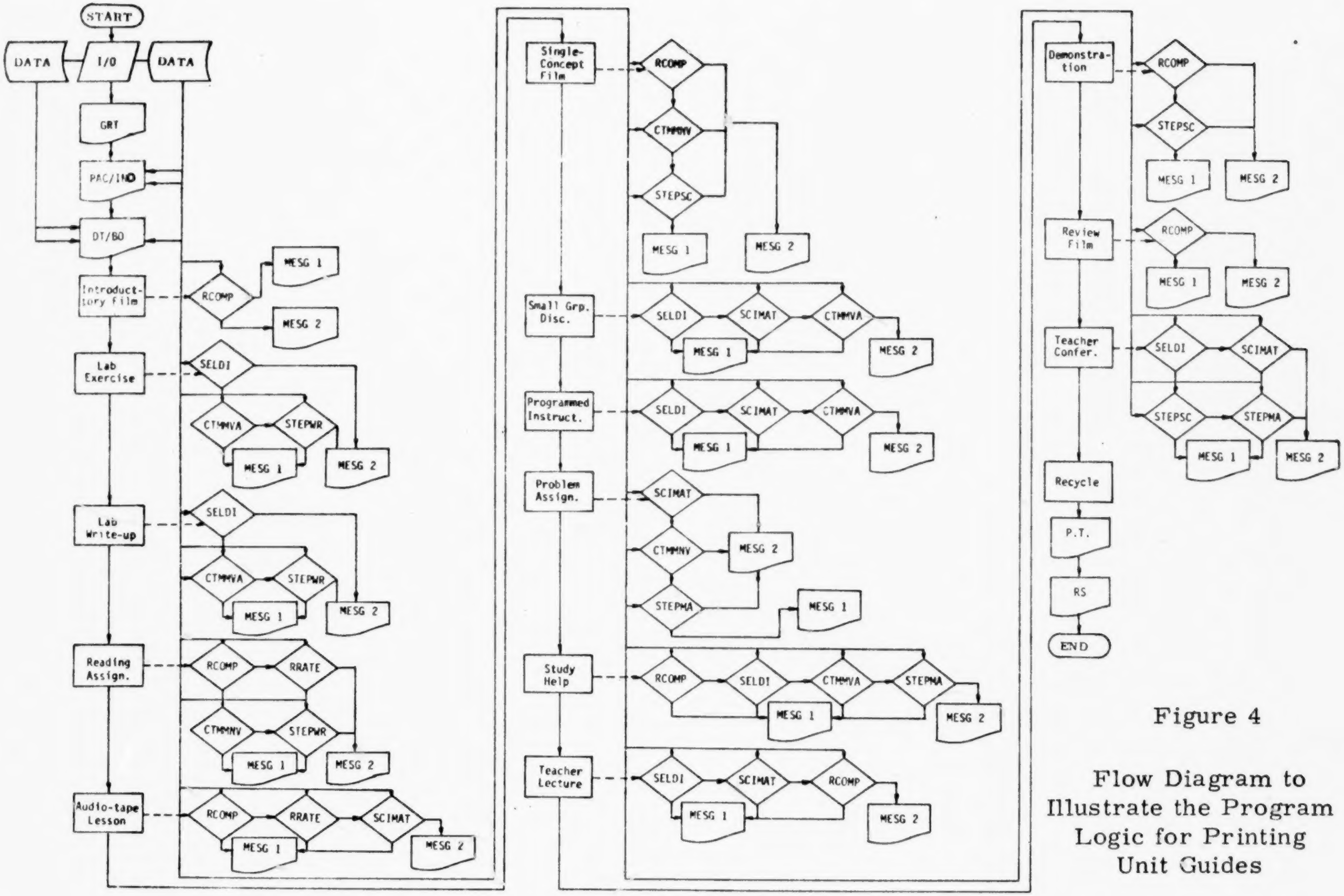

START
DATA
I/O
DATA
GRT
PAC/INO
DT/BO
Introductory Film
RCOMP
MESG 1
MESG 2
Lab Exercise
SELDI
CTMMVA
STEPWR
MESG 1
MESG 2
Lab Write-up
SELDI
CTMMVA
STEPWR
MESG 1
MESG 2
Reading Assign.
RCOMP
RRATE
CTMMNV
STEPWR
MESG 1
MESG 2
Audio-tape Lesson
RCOMP
RRATE
SCIMAT
MESG 1
MESG 2
Single-Concept Film
RCOMP
CTMMNV
STEPSC
MESG 1
MESG 2
Small Grp. Disc.
SELDI
SCIMAT
CTMMVA
MESG 1
MESG 2
Programmed Instruct.
SELDI
SCIMAT
CTMMVA
MESG 1
MESG 2
Problem Assign.
SCIMAT
CTMMNV
STEPMA
MESG 2
MESG 1
Study Help
RCOMP
SELDI
CTMMVA
STEPMA
MESG 1
MESG 2
Teacher Lecture
SELDI
SCIMAT
RCOMP
MESG 1
MESG 2
Demonstration
RCOMP
STEPSC
MESG 1
MESG 2
Review Film
RCOMP
MESG 1
MESG 2
Teacher Confer.
SELDI
SCIMAT
STEPSC
STEPMA
MESG 1
MESG 2
Recycle
P.T.
RS
END

Figure 4

Flow Diagram to Illustrate the Program Logic for Printing Unit Guides

Comment: Flowlines show operations sequence and dataflow direction. Arrowheads are required if path on any linkage is not left-to-right or top-to-bottom. Flowlines can cross, indicating they have no logical interrelation.

ABBREVIATIONS:

SELFDI = Self Direction Score

CTMMVA = California Test Mental Maturity Verbal Ability Score

CTMMNV = California Test Mental Maturity Non-Verbal Ability Score

STEPWR = S. T. E. P. Writing Score

STEPSC = S. T. E. P. Science Score

STEPMA = S. T. E. P. Math Score

SCIMAT = Science Math Honor Points

RRATE = Reading Rate Score

RCOMP = Reading Comprehension Score

MESG1 = Printed Instruction

MESG2 = Printed Instruction

I/O = Input

GRT = Greeting

PAC = Pacing

IND = Independence

DT = Diagnostic Pretest

BO = Behavioral Objectives

PT = Post-Treatment Test

RS = Recycle Statements

EXPLANATION OF THE COMPUTER LOGIC STRUCTURE TO PRODUCE A STUDENT'S STUDY GUIDE

The program was initiated by the input of data which provided the listing of objectives the student had selected. The statements related to the greeting (GRT), pacing (PAC), independence (IND), diagnostic pretest (DT), and list of all selected behaviorally stated objectives (BO) were then printed for the student.

The first behavioral objective was then listed and the fourteen ensuing learning activities were processed for that particular objective. For example, if the available resources to accomplish objective one included a film, laboratory exercise, readings, problems, and audio-tape segment, the resulting activities listed in the guide would indicate the availability of these resources.

The decision point behind the printed message for the introductory film was the student's reading comprehension score (RCOMP). This score was then compared with a criterion value. If the student's reading comprehension score was above or equal to this value, message two (MESG2) was printed. If the reading comprehension score was below the criterion value, message one (MESG1) was printed.

In the case of the laboratory exercise activity, either one or three decision points were processed in printing the message in the guide. If the student's self-direction score (SELDI) was above criterion, message two was printed. However, if the student's self-direction score was below criterion, but the CTMM verbal ability (CTMMVA) score and the STEP writing (STEPWR) score were both above criterion, message two was again printed. Conversely, if the SELDI, CTMMVA scores or SELDI, STEPWR scores were below criterion, message one was printed.

This decision making process was repeated for each of the activities. When no activity was listed for an objective, the message activated was a null character string and bypassed by the printer. After completing all fourteen activities, the program recycled back to the point where the next objective was printed and the activity decision structure was again initiated. After all objectives and related activities were printed, messages concerning the post-treatment test (PT) and recycle statements (RS) were printed. The program then proceeded to the next student's data and the process was repeated.

APPENDIX J

ITEMS FOR PRETEST
Chapter 19

1. The units for velocity are

(a) M/s (b) Km/hr. (c) cm/s (d) mile/year (e) all of these (f) none of these

2. A vector is used in physics to describe motion. Vector quantities have which of the following characteristics?

(a) size (magnitude)
(b) weight
(c) length
(d) direction
(e) a, b, and c
(f) a and d

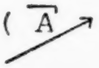
3. Acceleration may be defined algebraically by which of the following equations?

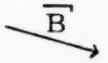
(a) $a = \frac{S}{T}$ (b) $a = \frac{V}{T}$ (c) $a = \frac{V}{T^2}$ (d) $a = VT$ (e) $a = ST$

4. The linear displacement of objects may have which of the following units?

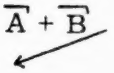
(a) m^3 (b) m^2 (c) m (d) cm/s (e) m/s^2

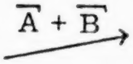
5. Vectors $\overline{A} + \overline{B}$ would approximately equal (

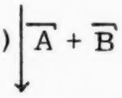


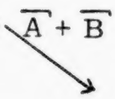


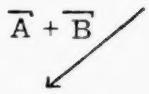
)

(a)

$\overline{A} + \overline{B}$

(b)

$\overline{A} + \overline{B}$

(c)

$\overline{A} + \overline{B}$

(d)

$\overline{A} + \overline{B}$

(e)

$\overline{A} + \overline{B}$

6. $\frac{1}{2}aT^2 + V_oT = ?$ The (?) in this equation represents

(a) velocity (V) (b) acceleration (a) (c) displacement (s) (d) Time (T) (e) area (A)

7. An example of a unit for acceleration is

(a) m/s (b) m^2/s (c) m/s^2 (d) m^2/s^2

8. A legitimate equation for obtaining velocity is

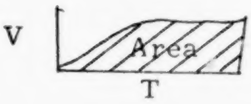
(a) $V = aT$ (b) $V = \frac{S}{T}$ (c) $V = \frac{a}{T}$ (d) $V = \frac{1}{2}aT^2$ (e) a and b

9. The combining of the following vector quantities $\overline{X}_1$ and $\overline{X}_2$ would yield which of the following?

($\overline{X}_1$ ⟶ $\overline{X}_2$ ⟵)

(a) ⟶
(b) ⟵
(c) ←
(d) ←————————
(e) ————————→

10. The area under a curve of a velocity vs. time graph



represents

(a) acceleration (b) instantaneous velocity
(c) average velocity (d) displacement

11. $? = \sqrt{V_o^2 + 2aS}$ The (?) in this expression represents

(a) displacement (S) (b) velocity (V)
(c) acceleration (a) (d) time (T)

12. The length of a vector represents what characteristic of the vector quantity?

(a) direction (b) magnitude (c) time (d) degrees

ITEMS FOR PRETEST
Chapter 20

1. The unit for force in the M. K. S. system is

   (a) pound (b) kilogram (c) newton (d) gram

2. The unit of inertial mass in the M. K. S. system is

   (a) pound (b) kilogram (c) newton (d) gram

3. The unit of gravitational mass in the M. K. S. system is

   (a) pound (b) kilogram (c) newton (d) gram

4. Newton's law of motion can be expressed algebraically in all but one of the following ways. Identify the equation that does not apply.

   (a) $F = ma$
   (c) $F \Delta T = m \Delta v$
   (b) $\overline{F} = \overline{ma}$
   (d) $F = m \dfrac{\Delta \overline{v}}{\Delta T}$
   (e) $F \Delta v = m \Delta T$

5. Under ideal conditions (no friction) an object moving at a constant speed of 1 m/s on a level surface will

   (a) gradually slow down and stop
   (b) move indefinitely at 1 m/s
   (c) gradually speed up

6. If an object of constant mass is accelerated $\frac{1}{2}$ m/s^2 by a force of 1 newton, what is the mass of the object?

   (a) .5 kg (b) 1 kg (c) 2 kg (d) 3 kg

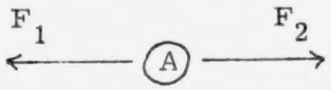
7. If an object of constant mass is accelerated $\frac{1}{2}$ m/s^2 by an initial force and on a second trial the same object is accelerated 1 m/s^2, what is the ratio of the force in the first trial to the force applied on the second trial?

   (a) 1/1 (b) 1/2 (c) 2/1

8. The change of velocity (Δ v) of an object is directly proportional to the (choose the best answer)

   (a) force applied
   (b) time interval the force is applied
   (c) mass of the object
   (d) A X B
   (e) A X B X C

9.



Object (A) has two forces acting upon it as diagrammed. What is the resultant force, when F_1 and F_2 are added vectorially?

(a) 0 F (b) 2 F (c) 1 F

APPENDIX K

COMPLETE LISTING OF TEST QUESTIONS FOR CHAPTER 19

QUEST. (1, 1) = Define inertia in a brief statement. In addition to the definition, cite an example of inertia of an object at rest or an example of inertia of an object in motion.

QUEST. (1, 2) = Explain briefly why driving on an icy highway is dangerous by using the principle of inertia in the explanation.

QUEST. (1, 3) = Diagram the force vectors acting upon an object to initiate motion. Also, diagram the force vectors acting upon an object in constant motion. Compare the diagrams and explain similarities and differences.

QUEST. (1, 4) = Same as Quest. (1, 5) below.

QUEST. (1, 5) = Automobile transmissions, whether automatic or manual, are similar in the sense that all have a series of "ranges" or "gears" depending on the type of transmission. Normally as the auto starts to move, the transmission is in low gear or low range. After speed is built up, the transmission is shifted either manually or automatically into a higher range or gear. How does this relate to inertia of objects at rest and later inertia of an object in motion? Explain. (Note: Low gear or low range yields greater power while high gear or high range is adapted for greater speed but less power.)

QUEST. (1, 6) = Explain why Galileo's principle of inertia was important to the evolution of the study of mechanics in physics.

QUEST. (2, 1) = A. Briefly explain the difference between kinematics and dynamics.

B. The following equation represents a basic kinematics equation. $? = V_oT + \frac{1}{2}aT^2$ What does the (?) in the equation represent?

(a) velocity (b) acceleration (c) displacement (d) time

C. Which of the graphs in Figure 1 describes an object moving with constant speed?

(a) a (b) b (c) c (d) d

QUEST. (2, 2) = A. The time rate of change of displacement is:

(a) velocity (b) speed (c) time (d) acceleration

B. The product of velocity and time is:

(a) velocity (b) displacement (c) acceleration

C. A car that has a mass of 2000 kg is moving with a velocity of 15 m/s in an easterly direction. If a force of 1000 newtons is briefly applied in a direction opposite to the direction of the car's motion, what will happen to the car's motion?

(a) The car will speed up.
(b) The car will slow down.
(c) The car will continue at the same speed but reverse directions.

QUEST. (2, 3) = A. A car is traveling on a level highway at a speed of 20 meters/second. A braking force of 3000 newtons brings the car to a stop in 10 seconds. The mass of the car is:

(a) 1500 kg (b) 2000 kg (c) 2500 kg (d) 3000 kg

B. A certain net force causes a 10 kg mass to accelerate at 20 m/s^2. The same force will cause a 5 kg mass to accelerate at what value?

(a) 9.8 m/s^2 (b) 10 m/s^2 (c) 25 m/s^2 (d) 40 m/s^2

QUEST. (2, 4) = Refer to figure 19-9 in the text (p. 325) for information important to this problem. Given the flash rate = 2.4 flashes/second, mass of puck assembly = 1 kg.

A. Determine the change of velocity of this system in cm/second.

(a) 4.5 (b) 8.4 (c) 11.4 (d) 20

B. Determine the force in newtons exerted by the two rubber bands.

(a) .05 (b) .08 (c) .11 (d) .20

QUEST. (2, 5) = Consider the following example. A 4 kg body is placed on an inclined plane with an angle of inclination of 30^{o}. Determine the acceleration of the weight if the plane is smooth. In solving this problem, develop and enumerate the necessary steps to solve this problem.

QUEST. (2, 6) = Kinematics and dynamics represent two content areas in basic physics. The study of which of these topics has contributed the most to man's technological achievements? Explain.

QUEST. (3, 1) = Define inertial mass in a brief statement.

QUEST. (3, 2) = Which of the following best describes the difference between inertial and gravitational mass?

(a) They are inversely proportional.
(b) They are measured differently.
(c) They are exactly the same.
(d) The units are different.

QUEST. (3, 3) = A force of 6 newtons acts upon a mass of x kilograms. The resulting acceleration of this mass is . 1 meters/second squared. What is the mass of the object?

(a) 6 kg (b) 60 kg (c) . 6 kg (d) . 06 kg

QUEST. (3, 4) = Compare and contrast inertial mass and gravitational mass in terms of the related concepts: units, additive masses, conservation of mass, volume of substance.

QUEST. (3, 5) = Is there any difference between inertial and gravitational mass since they have the same units? Explain.

QUEST. (3, 6) = Same as Quest. (3, 5) above.

QUEST. (4, 1) = A. The unit of force in the M. K. S. system of measurement is:

(a) pounds (b) dynes (c) newtons (d) kilograms

B. State Newton's Law of Motion.

QUEST. (4, 2) = When the units of mass are expressed kilograms (kg) and the units of acceleration are meters/second squared (m/s^2). What are the derived units of force?

(a) m/s^2 (b) $kg\text{-}m/s^2$ (c) kg-m/s (d) kg/s

QUEST. (4, 3) = A. A force of .6 newtons acts upon a mass of .30 kilograms. The resulting acceleration of this mass in meters/second squared is

(a) .18 (b) .50 (c) 1.0 (d) 2.0

B. A force of 2 newtons acting upon a body for 6 seconds produces a change in velocity of 12 meters per second. The mass of the body in kilograms is

(a) .5 (b) 1 (c) 12 (d) 24

C. The force in newtons required to give a mass of 25 kilograms an acceleration of 2 meters per second squared is

(a) .08 (b) 12.5 (c) 27 (d) 50

QUEST. (4, 4) = A. Three forces act from a single point. One force is 300 newtons due north, a second force is 500 newtons due east, and a third force is 100 newtons due west. The magnitude in newtons of the resultant force is

(a) 100 (b) 300 (c) 500 (d) 582

B. A block weighing 10 newtons is held motionless on a frictionless inclined plane which makes an angle of 30^o with the horizontal. The force parallel to the incline needed to hold the block in position is

(a) 0 newtons (b) 5 newtons (c) 10 newtons (d) 20 newtons

QUEST. (4, 5) = A car is traveling on a level highway at the speed of 15 meters per second. A braking force of 3000 newtons brings the car to a stop in 10 seconds. The mass of the car is

(a) 1500 kg (b) 2000 kg (c) 2500 kg (d) 3000 kg

QUEST. (4, 6) = In a brief paragraph, evaluate the usefulness and generalizability of F=MA to describe the dynamics aspect of molecular motion compared with the motion of planets around the sun.

QUEST. (5, 1) = State Newton's Law utilizing vector notation to show vector quantities.

QUEST. (5, 2) = Which vector in Figure 2 best represents the result of forces F_1 and F_2 acting on point P?

(a) A (b) B (c) C (d) D

QUEST. (5, 3) = The resultant of two forces acting on the same point is a maximum when the angle between the two forces is

(a) 0° (b) 45° (c) 90° (d) 180°

QUEST. (5, 4) = A. A box rests on a plank which is initially lying horizontal on a flat surface; one end of the plank is then raised until the angle between the plank and the surface is 45°. Diagram the forces acting upon the box initially while the plank is horizontal, and again when the plank makes a 45° angle with the surface.

B. How does the component of the weight of the box parallel to the plank compare in the two diagrams?

QUEST. (5, 5) = Diagram all of the force vectors in the accompanying Figure 3 at points A, B, and C. Since vector arrows are being used, remember to illustrate magnitudes of the forces at the three points.

QUEST. (5, 6) = If several forces of different magnitudes and directions act on an object in what direction will the object accelerate? If you were to solve this problem, which method of solution (vector addition or algebraic solution) would you use? Explain.

FIGURE SHEET FOR CHAPTER 19

FIGURE 1

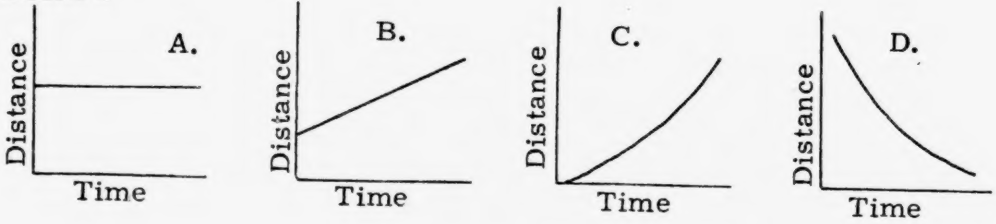


FIGURE 2

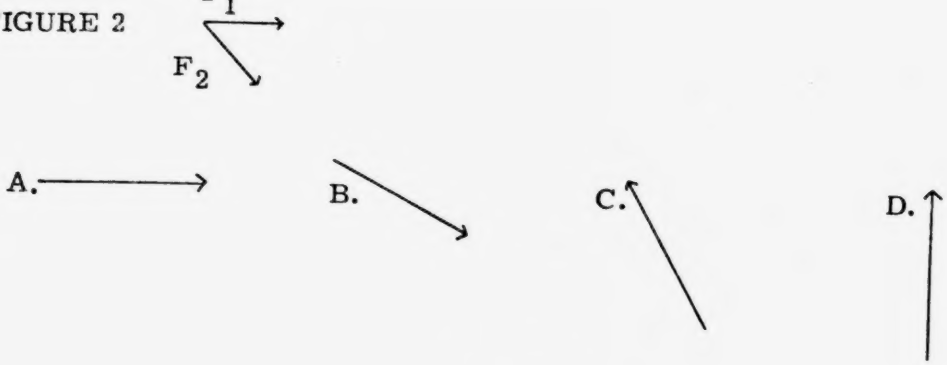
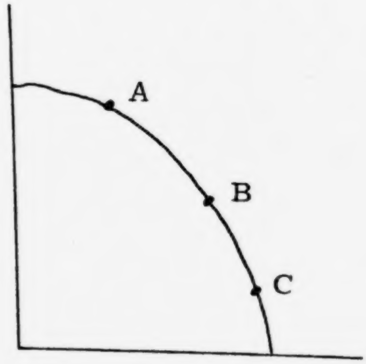


FIGURE 3



COMPLETE LISTING OF TEST QUESTIONS FOR CHAPTER 20

QUEST. (1, 1) = A. The inertial mass of an object depends upon which of the following?

(a) The position of the object.
(b) The gravitational acceleration value.
(c) The force required to move it from rest.
(d) The force required to lift the object.

B. Units of inertial and gravitational mass are

(a) unequal (b) equivalent

QUEST. (1, 2) = A. "The weight of a barrel is 55 kg." Discuss in a brief paragraph the misconception that appears in the following statement: The weight of a barrel is 55kg.

B. What is the weight in newtons of a 100 kg man?

(a) 500 nt (b) 700 nt (c) 900 nt (d) 980 nt

QUEST. (1, 3) = A. A block with a mass of 2 kg rests on a horizontal table. The force exerted by the table upon the mass is

(a) 0 newtons (b) 2 newtons (c) 9.8 newtons (d) 19.6 newtons

B. A trunk of 100 kg is resting upon a set of warehouse scales. What is the weight of the trunk in newtons?

(a) 980 newtons (b) 100 newtons (c) 98 newtons
(d) 490 newtons

QUEST. (1, 4) = Discuss two factors that cause gravitational force fluctuations on the earth's surface. State the factor, and state whether this factor would increase or decrease gravitational attraction.

QUEST. (1, 5) = Briefly propose a reason to explain why the gravitational force decreases at increasing distances from the earth.

QUEST. (1, 6) = Develop an argument to clarify the confusion on the meaning of mass and weight. Include in this answer a reason for the confusion of these terms' definitions.

QUEST. (2, 1) = What is the magnitude of the gravitational force of the earth on a 1 kg object at a point where the acceleration of gravity is 9.80 m/s^2?

(a) 9.8 newtons (b) 9.8 joule (c) 9.8 watt (d) 9.8 ampere

QUEST. (2, 2) = One nt/kg is equivalent to one:

(a) m/s^2 (b) m/s (c) nt-kg (d) nt/s

QUEST. (2, 3) = A baseball is thrown vertically downward from the top of a 150 m tower with an initial velocity of 20 m/s. What is the final velocity of the ball just before striking the earth?

(a) 50 m/s (b) 58 m/s (c) 65 m/s (d) 70 m/s

QUEST. (2, 4) = Describe in a brief paragraph the characteristics in common of free fall to objects moving over a horizontal surface with a constant horizontal force applied.

QUEST. (2, 5) = A projectile is fired directly upward with a velocity of 98 m/s. The projectile will reach a maximum height of:

(a) 980 m (b) 498 m (c) 245 m (d) 98 m

QUEST. (2, 6) = Discuss the factors and given quantities that are different for dynamics problems involving free fall compared with problems dealing with horizontal motion.

QUEST. (3, 1) = Cite two examples of motion that illustrate the independence of the vertical and horizontal components of projectile motion.

QUEST. (3, 2) = $d = \frac{1}{2}gT^2$ is the kinematic expression of calculate:

(a) the vertical displacement of projectile motion.
(b) the horizontal displacement of projectile motion.
(c) the total displacement of projectile motion.
(d) the actual path of projectile motion.

QUEST. (3, 3) = During World War I there was a famous gun known as Big Bertha that had a maximum range of 120 km. Assuming the gun's barrel was inclined 45 degrees to achieve this maximum range, and the muzzle velocity was 1000 m/s, what height did the shell reach in traveling this distance?

(a) 20 km (b) 25 km (c) 30 km (d) 35 km

QUEST. (3, 4) = Refer to Figure 1 to answer this problem. Carefully indicate and label the forces acting on a projectile while at points A and B as it moves through the air.

QUEST. (3, 5) = A player kicks a football at an angle of 37^o with the horizontal and with an initial velocity of 45 ft/s. An opposing player facing the kicker is standing at a distance of 100 ft. from the kick. How far must the receiver run in order to catch the kicked ball?

(a) 12 ft. (b) 23 ft. (c) 34 ft. (d) 42 ft.

QUEST. (3, 6) = Describe in a brief paragraph why the vertical and horizontal components of projectile motion are independent using Newton's law of motion as a basis for the explanation.

QUEST. (4, 1) = Solving the expression, MV^2/R yields a quantity of

(a) acceleration (b) velocity (c) force (d) displacement

QUEST. (4, 2) = What is the relationship between $V = 2\pi R/T$ and V^2/R? Include in your explanation a diagram to illustrate the quantities discussed in your answer.

QUEST. (4, 3) = The innermost of Saturn's nine moons, Mimas, has a fairly circular orbit of radius 1.87×10^5 km and a period of about 23 hours. Find the velocity of Mimas.

(a) 5.1×10^3 km/hr.
(b) 5.1×10^4 km/hr.
(c) 5.5×10^4 km/hr.
(d) 6×10^5 km/hr.

QUEST. (4, 4) = Refer to Figure 2 on the accompanying sheet to answer these questions.

A. Diagram the forces acting upon the stopper in circular motion.

B. What happens to the magnitude of the force if the radius of the orbit of the stopper is decreased by $\frac{1}{2}$?

C. What happens to the magnitude of the force if the radius of the stopper is decreased by $\frac{1}{2}$ and the orbital speed of the stopper is decreased by $\frac{1}{2}$?

QUEST. (4, 5) = Derive and explain an equation for centripetal acceleration where the acceleration is directly proportional to the radius and inversely proportional to the period.

QUEST. (4, 6) = A body moving with a speed V is acted upon by a force that always acts perpendicular to the motion of the body. This force is constant in magnitude.

A. Draw a sketch of the trajectory.

B. Does the speed of the object increase, decrease, or remain unchanged?

QUEST. (5, 1) = The period of a pendulum depends upon:

(a) mass of pendulum bob
(b) density of pendulum wire
(c) length of pendulum wire

QUEST. (5, 2) = $F=-KX$ and $F=M4\pi^2/T^2R$ are equivalent force equations in comparing harmonic motion to circular motion. Since the two equations are equivalent, what is the expression for K?

(a) $M4\pi/T^2$

(b) $M4\pi^2/T^2$

(c) $M4\pi^2/R$

(d) $M4\pi^2/T$

QUEST. (5, 3) = How many single swings per minute will a pendulum 1m long make at a point on the earth's surface where $G=9.8\ m/s^2$?

(a) 2 (b) 10 (c) 30 (d) 60

QUEST. (5, 4) = A 150 gram mass, when hung on a long and light spiral spring stretches it 40 cm. Determine the spring's period of vibration if it is pulled down a little (small extension) and then released. (Use the equations $F = -KX$, and $T = 2\pi\sqrt{M/K}$ in your solution.)

(a) 1.27 sec. (b) 1.45 sec. (c) 1.5 sec. (d) 1.6 sec.

QUEST. (5, 5) = Develop an argument which includes 2 reasons to explain why single harmonic motion is more complex than circular motion.

QUEST. (5, 6) = Show algebraically how $F = ma$ can be expressed as $F = -KX$. (Hint: List the algebraic steps to convert $V = 2\pi R/T$ into centripetal acceleration.)

QUEST. (6, 1) = An inertial frame of reference is one that:

(a) is stationary
(b) moves in a straight line (unaccelerated)
(c) moves in a circular path
(d) a and b
(e) none of these

QUEST. (6, 2) = Explain in a short paragraph, why contradictory observations of motion of an object occur from 2 different frames of reference.

QUEST. (6, 3) = Explain in a brief paragraph why an involute is produced from drawing a "straight line" on a rotating sheet of paper.

QUEST. (6, 4) = Refer to Figure 3 on the accompanying sheet to answer the following question. Draw the force vectors acting upon a bicyclist as he goes around a corner as seen from his position and as seen from outside the cyclist-bicycle system.

QUEST. (6, 5) = Suppose a new force field electrical in nature would appear next week. Would this force field affect the validity of Newton's laws of motion? Explain briefly.

QUEST. (6, 6) = Why is Newton's Law only true in an non-inertial frame of reference?

FIGURE SHEET FOR CHAPTER 20

Note: Your test may contain one or more questions that request you to use the accompanying sheet with figures on it. Use only the figures indicated on the test you are using. Some tests may not use any of the figures.

FIGURE 1

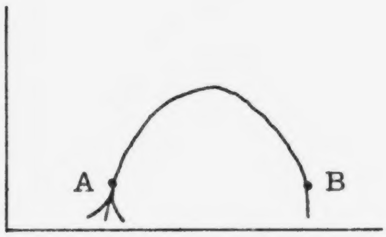


FIGURE 2

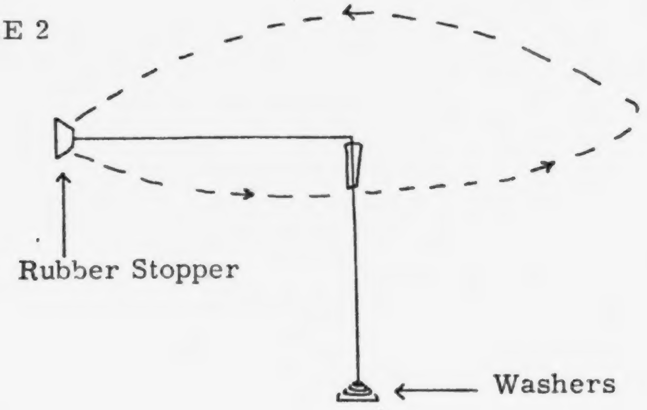
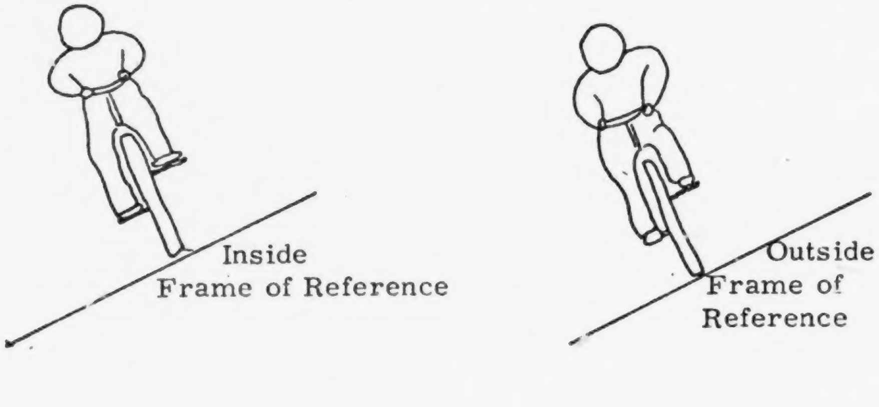

Rubber Stopper
Washers

FIGURE 3


Inside
Frame of Reference
Outside
Frame of
Reference

MICKY BOTNER

CHAPTER 19 QUIZ

MICKY THIS QUIZ WAS DEVELOPED FROM THE OBJECTIVES YOU AND MR. DAILY SELECTED FOR YOUR LEARNING PROGRAM. AFTER YOU COMPLETE THIS QUIZ, TAKE IT TO MR. DAILY FOR IMMEDIATE SCORING AND DIAGNOSIS.

DIRECTIONS: THE FOLLOWING QUESTIONS WERE PRINTED BY THE COMPUTER. YOU WILL NOTICE THAT SOME OF THE QUESTIONS ARE MULTIPLE CHOICE WHILE OTHERS ARE ESSAY OR SHORT ANSWER. SINCE NO SPACE IS PROVIDED FOLLOWING EACH QUESTION, PLEASE RESPOND TO THE ESSAY AND SHORT ANSWER QUESTIONS ON A SEPARATE SHEET THAT IS ATTACHED. PLEASE CIRCLE YOUR ANSWER CHOICE ON THE MULTIPLE CHOICE ITEMS.

1. AUTOMOBILE TRANSMISSIONS, WHETHER AUTOMATIC OR MANUAL, ARE SIMILAR IN THE SENSE THAT ALL HAVE A SERIES OF 'RANGES' OR 'GEARS' DEPENDING UPON THE TYPE OF TRANSMISSION. NORMALLY, AS THE AUTO STARTS TO MOVE THE TRANSMISSION IS IN LOW GEAR OR LOW RANGE. AFTER SPEED IS BUILT UP THE TRANSMISSION IS SHIFTED EITHER MANUALLY OR AUTOMATICALLY INTO A HIGHER RANGE OR GEAR. HOW DOES THIS RELATE TO INERTIA OF OBJECTS AT REST AND LATER INERTIA OF AN OBJECT IN MOTION. EXPLAIN. (NOTE: LOW GEAR OR LOW RANGE YIELDS GREATER POWER WHILE HIGH GEAR OR HIGH RANGE IS ADAPTED FOR GREATER SPEED BUT LESS POWER.)

2. REFER TO FIGURE 19-9(PAGE 325) FOR INFORMATION RELATING TO THIS PROBLEM. GIVEN: FLASH RATE =2.4 FLASHES/SECOND, MASS OF PUCK ASSEMBLE= 1KG

   A. DETERMINE THE CHANGE OF VELOCITY OF THIS SYSTEM IN CM/SEC.

   A.4.5 B.8.4 C.11.4 D.20

   B. DETERMINE THE FORCE IN NEWTONS EXERTED BY THE RUBBER BANDS.

   A .05 B .08 C .11 D .20

3. COMPARE AND CONTRAST INERTIAL MASS AND GRAVITATIONAL MASS IN TERMS OF THE RELATED CONCEPTS: UNITS, ADDITIVE MASSES, CONSERVATION, VOLUME OF THE SUBSTANCE.

4. A CAR IS TRAVELING ON A LEVEL HIGHWAY AT THE SPEED OF 15 METERS/SECOND. A BRAKING FORCE OF 3000 NEWTONS BRINGS THE CAR TO A STOP IN 10 SECONDS. THE MASS OF THE CAR IS:

   A. 1500 KG B. 2000 KG C. 2500 KG D. 3000 KG

5. DIAGRAM ALL OF THE FORCE VECTORS ON FIGURE 2 OF THE ACCOMPANYING SHEET AT POINTS A, B, AND C. SINCE VECTOR ARROWS ARE BEING USED REMEMBER TO ILLUSTRATE MAGNITUDES OF THE FORCES AT THE THREE POINTS.

RICK HASEMAN

CHAPTER 19 QUIZ

RICK THIS QUIZ WAS DEVELOPED FROM THE OBJECTIVES YOU AND MR. DAILY SELECTED FOR YOUR LEARNING PROGRAM. AFTER YOU COMPLETE THIS QUIZ, TAKE IT TO MR. DAILY FOR IMMEDIATE SCORING AND DIAGNOSIS.

DIRECTIONS: THE FOLLOWING QUESTIONS WERE PRINTED BY THE COMPUTER. YOU WILL NOTICE THAT SOME OF THE QUESTIONS ARE MULTIPLE CHOICE WHILE OTHERS ARE ESSAY OR SHORT ANSWER. SINCE NO SPACE IS PROVIDED FOLLOWING EACH QUESTION, PLEASE RESPOND TO THE ESSAY AND SHORT ANSWER QUESTIONS ON A SEPARATE SHEET THAT IS ATTACHED. PLEASE CIRCLE YOUR ANSWER CHOICE ON THE MULTIPLE CHOICE ITEMS.

1. EXPLAIN WHY GALILEO'S PRINCIPLE OF INERTIA WAS IMPORTANT TO THE EVOLUTION OF THE STUDY OF MECHANICS IN PHYSICS.

2. KINEMATICS AND DYNAMICS REPRESENT TWO CONTENT AREAS IN BASIC PHYSICS. THE STUDY OF WHICH OF THESE TOPICS HAVE CONTRIBUTED MOST TO MAN'S TECHNOLOGICAL ACHIEVEMENTS. EXPLAIN.

3. IS THERE ANY DIFFERENCE BETWEEN INERTIAL AND GRAVITATIONAL MASS SINCE THEY HAVE THE SAME UNITS? EXPLAIN.

4. IN A BRIEF PARAGRAPH, EVALUATE THE USEFULNESS AND GENERALIZABILITY OF F=MA TO DESCRIBE THE DYNAMICS ASPECTS OF MOLECULAR MOTION, COMPARED WITH THE MOTION OF PLANETS AROUND THE SUN.

5. IF SEVERAL FORCES OF DIFFERENT MAGNITUDES AND DIRECTIONS ACT ON AN OBJECT IN WHICH DIRECTION WOULD THE OBJECT ACCELERATE? IF YOU WERE TO SOLVE THIS PROBLEM WHICH METHOD OF SOLUTION(VECTOR ADDITION OR ALGEBRAIC SOLUTION) WOULD YOU USE. EXPLAIN.

DALE BIVENS

CHAPTER 20 QUIZ

DALE THIS QUIZ WAS DEVELOPED FROM THE OBJECTIVES YOU AND MR. DAILY SELECTED FOR YOUR LEARNING PROGRAM. AFTER YOU COMPLETE THIS QUIZ, TAKE IT TO MR. DAILY FOR IMMEDIATE SCORING AND DIAGNOSIS.

DIRECTIONS: THE FOLLOWING QUESTIONS WERE PRINTED BY THE COMPUTER. YOU WILL NOTICE THAT SOME OF THE QUESTIONS ARE MULTIPLE CHOICE WHILE OTHERS ARE ESSAY OR SHORT ANSWER. SINCE NO SPACE IS PROVIDED FOLLOWING EACH QUESTION, PLEASE RESPOND TO THE ESSAY AND SHORT ANSWER QUESTIONS ON A SEPARATE SHEET THAT IS ATTACHED. PLEASE CIRCLE YOUR ANSWER CHOICE ON THE MULTIPLE CHOICE ITEMS.

1. DISCUSS TWO FACTORS THAT CAUSE GRAVITATIONAL FORCE FLUCTUATIONS ON THE EARTH'S SURFACE. STATE EACH FACTOR, AND STATE WHETHER THIS FACTOR WOULD INCREASE OR DECREASE GRAVITATIONAL ATTRACTION.

2. DESCRIBE IN A BRIEF PARAGRAPH THE CHARACTERISTICS IN COMMON OF OBJECTS IN FREEFALL TO OBJECTS MOVING OVER A HORIZONTAL SURFACE WITH A CONSTANT HORIZONTAL FORCE APPLIED.

3. REFER TO FIGURE 1 ON THE ACCOMPANYING SHEET TO ANSWER THIS PROBLEM. CAREFULLY DRAW AND LABEL THE FORCES ACTING ON A PROJECTILE WHILE AT POINTS A AND B AS IT MOVES THROUGH THE AIR.

4. THE INNERMOST OF SATURN'S NINE MOONS, MIMAS, HAS A FAIRLY CIRCULAR ORBIT OF RADIUS 187,000 KM AND A PERIOD OF ABOUT 23 HOURS. FIND THE VELOCITY OF MIMAS.

A. 5,100 KM/HR
B. 51,000 KM/HR
C. 55,000 KM/HR
D. 600,000 KM/HR

5. HOW MANY SINGLE SWINGS PER MINUTE WILL A PENDULUM 1 METER LONG MAKE AT A POINT ON THE EARTH'S SURFACE WHERE G= 9.8 M/S2?

A. 2 B. 10 C. 30 D. 60

6. REFER TO FIGURE 3 ON THE ACCOMPANYING SHEET TO ANSWER THE FOLLOWING QUESTION. DRAW THE FORCE VECTORS ACTING UPON A BICYCLIST AS HE GOES AROUND A CORNER AS SEEN FROM HIS POSITION, AND AS SEEN FROM OUTSIDE THE CYCLIST-BICYCLE SYSTEM.

MICKY BOTNER

CHAPTER 20 QUIZ

MICKY THIS QUIZ WAS DEVELOPED FROM THE OBJECTIVES YOU AND MR. DAILY SELECTED FOR YOUR LEARNING PROGRAM. AFTER YOU COMPLETE THIS QUIZ, TAKE IT TO MR. DAILY FOR IMMEDIATE SCORING AND DIAGNOSIS.

DIRECTIONS: THE FOLLOWING QUESTIONS WERE PRINTED BY THE COMPUTER. YOU WILL NOTICE THAT SOME OF THE QUESTIONS ARE MULTIPLE CHOICE WHILE OTHERS ARE ESSAY OR SHORT ANSWER. SINCE NO SPACE IS PROVIDED FOLLOWING EACH QUESTION, PLEASE RESPOND TO THE ESSAY AND SHORT ANSWER QUESTIONS ON A SEPARATE SHEET THAT IS ATTACHED. PLEASE CIRCLE YOUR ANSWER CHOICE ON THE MULTIPLE CHOICE ITEMS.

1. BRIEFLY PROPOSE A REASON TO EXPLAIN WHY THE GRAVITATIONAL FORCE DECREASES AT INCREASING DISTANCES FROM THE EARTH.

2. DESCRIBE IN A BRIEF PARAGRAPH THE CHARACTERISTICS IN COMMON OF OBJECTS IN FREEFALL TO OBJECTS MOVING OVER A HORIZONTAL SURFACE WITH A CONSTANT HORIZONTAL FORCE APPLIED.

3. A PLAYER KICKS A FOOTBALL AT AN ANGLE OF 37 DEGREES WITH THE HORIZONTAL WITH AN INITIAL VELOCITY OF 48 FT/S. AN OPPOSING PLAYER, FACING THE KICKER IS STANDING AT A DISTANCE OF 100 FEET FROM THE KICKER TO RECEIVE THE KICK. HOW FAR MUST THE RECEIVER RUN IN ORDER TO CATCH THE KICKED FOOTBALL?

A. 12 FT B. 23 FT C. 34 FT D. 42 FT

4. THE INNERMOST OF SATURN'S NINE MOONS, MIMAS, HAS A FAIRLY CIRCULAR ORBIT OF RADIUS 187,000 KM AND A PERIOD OF ABOUT 23 HOURS. FIND THE VELOCITY OF MIMAS.

A. 5,100 KM/HR
B. 51,000 KM/HR
C. 55,000 KM/HR
D. 600,000 KM/HR

5. HOW MANY SINGLE SWINGS PER MINUTE WILL A PENDULUM 1 METER LONG MAKE AT A POINT ON THE EARTH'S SURFACE WHERE G= 9.8 M/S2?

A. 2 B. 10 C. 30 D. 60

6. EXPLAIN IN A BRIEF PARAGRAPH WHY AN INVOLUTE IS PRODUCED FROM DRAWING A STRAIGHT LINE ON A ROTATING SHEET OF PAPER.

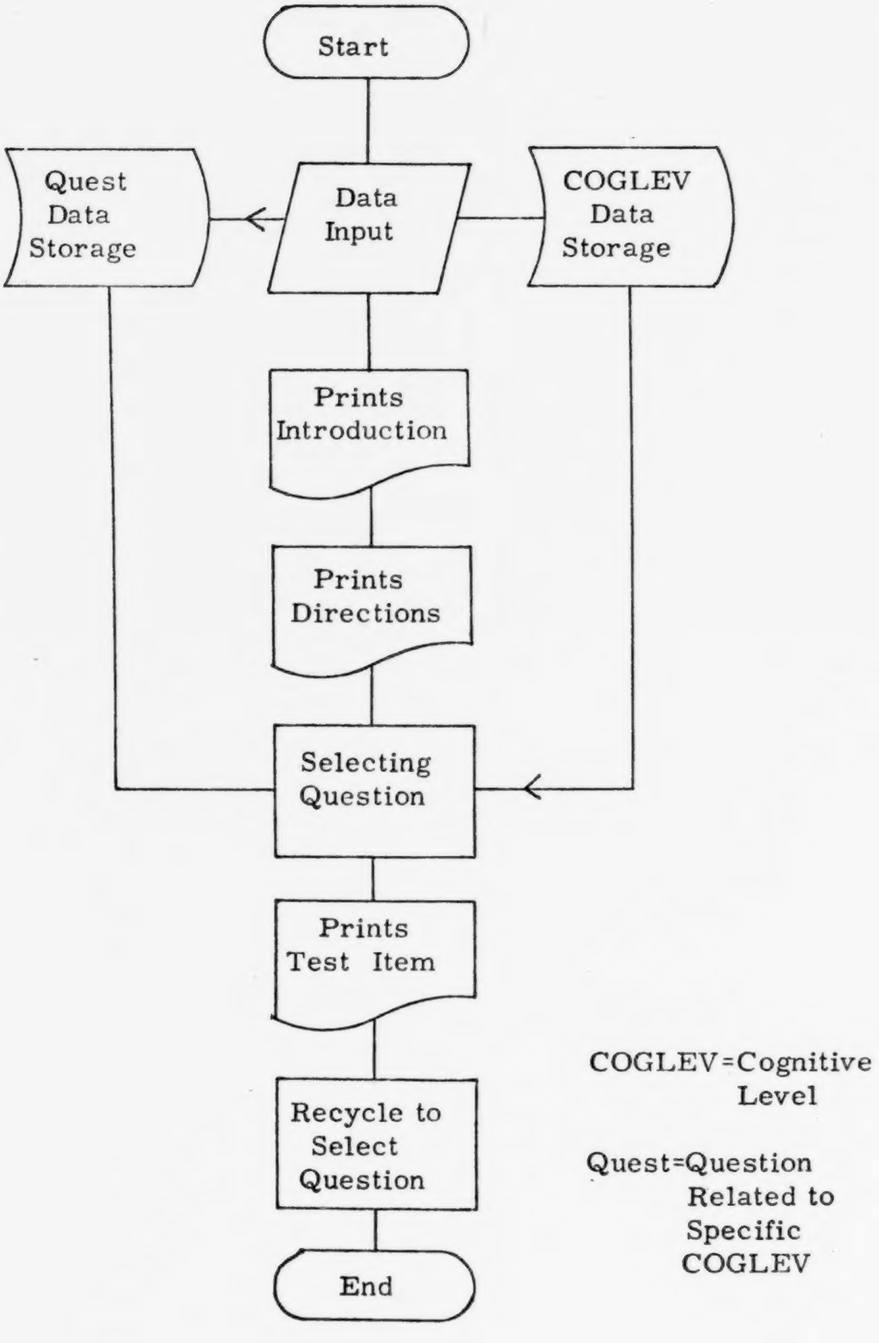

Start
Quest Data Storage
Data Input
COGLEV Data Storage
Prints Introduction
Prints Directions
Selecting Question
Prints Test Item
Recycle to Select Question
End
COGLEV=Cognitive Level
Quest=Question Related to Specific COGLEV

Figure 5

Flow Diagram to Illustrate the Program Logic for Printing Unit Tests

APPENDIX L

PHYSICS

NEWTON'S LAW OF MOTION
CHAPTER 19

THIS STUDY GUIDE IS PRINTED
ESPECIALLY FOR MICKY
BOTNER

204 SONDRA AV.

COLUMBIA, MISSOURI
65201

FIRST SEMESTER

1971

DAVID H. HICKMAN HIGH SCHOOL

NORTH HALL ROOM 110

TEACHER: MR. WILLIAM DAILY

NEWTON'S LAW OF MOTION
CHAPTER 19

THIS IS A SPECIAL INDIVIDUALIZED PROGRAM WRITTEN FOR MICKY BOTNER.

MICKY, THIS GUIDE HAS BEEN PREPARED FOR YOU USING INFORMATION FROM THE TESTS ADMINISTERED DURING THE INITIAL WEEKS OF SCHOOL AND YOUR PAST PERFORMANCE IN SCIENCE AND MATHEMATICS. THE TASKS RECOMMENDED IN THIS GUIDE SHOULD BE INTERESTING AND CHALLENGING. THE ACTIVITIES, PROBLEMS, LABS, FILMS AND READING MATERIALS THAT ARE SUGGESTED SHOULD ASSIST YOU GREATLY IN UNDERSTANDING THE BASIC IDEAS OF MECHANICS.

INDEX NUMBERS				TIME ALLOWED
1	2	1	2	1.0 X THE TEACHER'S GUIDE FIGURE

SINCE THIS GUIDE COVERS ONE CHAPTER, FOR YOU TO COMPLETE IT WILL PROBABLY REQUIRE 10 DAYS.

THOUGH SOME OF THE PHYSICS STUDENTS WILL PROBABLY GO ELSEWHERE TO STUDY WILL YOU PLEASE STAY IN ROOM 110 SO MR. DAILY MAY ASSIST YOU WHEN IT SEEMS NECESSARY.

ARRANGE TO TAKE THE PRETEST FOR CHAPTER 19, NEWTON'S LAW OF MOTION. TRY EARNESTLY TO SOLVE EACH PROBLEM AND YOU WILL REMEMBER IT LATER AS YOU STUDY THE CHAPTER.

OBJECTIVES FOR THIS CHAPTER

THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE PRINCIPLE OF INERTIA. I WILL BE ABLE TO DEVELOP AN ORIGINAL TECHNIQUE THAT DEMONSTRATES INERTIA OF MOTION IN THE LABORATORY SETTING. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE MOTION OF AN OBJECT WHEN BALANCED AND UNBALANCED FORCES ACT UPON IT. I WILL BE ABLE TO DETERMINE THE CHANGE IN VELOCITY AND THE RESULTING APPLIED FORCE ACTING UPON THE OBJECT THROUGH CAREFUL STUDY OF MULTI-EXPOSURE PHOTOGRAPHS OF THE MOVING OBJECT. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

THE CONTENT OF THIS OBJECTIVE IS RELATED TO: MOTION OF AN OBJECT WHEN THE MASS OF THE OBJECT CHANGES WHILE A

CONSTANT FORCE IS APPLIED TO IT. I WILL BE ABLE TO OUTLINE THE CHARACTERISTICS OF INERTIAL AND GRAVITATIONAL MASS THAT ARE SIMILAR (ADDITIVE MASSES, UNITS, CONSERVATION DURING CHEMICAL CHANGE, VOLUME OF SUBSTANCE) AND DISTINGUISH WHY INERTIAL AND GRAVITATIONAL MASS ARE NOT THE SAME. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

THE CONTENT OF THIS OBJECTIVE IS RELATED TO NEWTON'S LAW AND THE UNIT OF FORCE. I WILL BE ABLE TO SOLVE COMPLEX DYNAMICS PROBLEMS WHICH REQUIRE AN INITIAL SOLUTION TO YIELD THE DATA TO SOLVE THE PRIMARY PROBLEM. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

THE CONTENT OF THIS OBJECTIVE IS RELATED TO FORCE VECTORS AND NEWTON'S LAW. I WILL BE ABLE TO DEVISE A FORCE VECTOR DIAGRAM TO DESCRIBE ALL THE VECTOR COMPONENTS ACTING UPON A PROJECTILE MOVING THROUGH THE EARTH'S ATMOSPHERE. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 1
THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE PRINCIPLE OF INERTIA. I WILL BE ABLE TO DEVELOP AN ORIGINAL TECHNIQUE THAT DEMONSTRATES INERTIA OF MOTION IN THE LABORATORY SETTING. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 2
ASK MR.DAILY ABOUT THE FILM 'FORCES'. THIS FILM EXAMINES THE GENERAL NATURE OF GRAVITATIONAL AND ELECTRIC FORCES. THE FILM WILL BE SCHEDULED IN THIS CHAPTER FOR A 'GROUPIE' (LARGE GROUP SHOWING).

STEP 3
READ SECTIONS 19/1-19/2 IN THE TEXT. IN ADDITION, READ GALILEO'S DISCUSSION OF PROJECTILE MOTION.- P. 105-107 IN PROJECT PHYSICS READER 1.

STEP 4
PLEASE LISTEN TO AUDIO-TAPE 19-1-A. AS YOU LISTEN TO THE TAPE OPEN YOUR TEXT TO SECTIONS 19/1-19/2. AFTER LISTENING TO THE TAPE PLEASE REWIND IT.

STEP 5
DISCUSS GALILEO'S ARGUMENT OF OBJECTS MOVING ON INCLINES WITH OTHER MEMBERS IN CLASS. THIS WAS DISCUSSED IN SECTION 19/2 AND IN THE PROJECT PHYSICS READER.

STEP 6
STUDY THE PROGRAMMED MATERIAL FROM SECTION 7 -DEFINITION OF FORCES (PAGES 95-101), AND SECTION 8 -NEWTON'S FIRST LAW OF MOTION:MOTION ON A FRICTIONLESS SURFACE (PAGES 101-107). ASK MR. DAILY FOR THIS MATERIAL.

STEP 7
WORK THE FOLLOWING PROBLEMS: 2,3,5 ON P. 332 OF THE TEXT. CHECK YOUR SOLUTIONS WITH THE ANSWERS IN THE HOMEWORK NOTEBOOK THEN TURN IN YOUR PAPER FOR CREDIT RECORDING.

STEP 8
SEE YOUR TEACHER FOR A STUDY HELP APPOINTMENT SLIP IF YOU FEEL YOU NEED EXTRA HELP, MORE TIME TO STUDY, OR ADDITIONAL GUIDANCE IN WORKING IN THE INDIVIDUAL MODE.

STEP 9
SEEK A PARTNER OR SMALL GROUP TO JOIN TO OBSERVE AND INTERPRET A DEMONSTRATION ON INERTIA. CHECK WITH MR. DAILY ABOUT A SET OF INSTRUCTIONS TO FOLLOW TO PERFORM THE DEMONSTRATION.

STEP 10
YOUR TEACHER WILL BE GLAD TO DISCUSS ANY PROBLEMS YOU MAY BE HAVING AT THIS POINT----GO BUG HIM.

STEP 11
STEP 12
THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE MOTION OF AN OBJECT WHEN BALANCED AND UNBALANCED FORCES ACT UPON IT. I WILL BE ABLE TO DETERMINE THE CHANGE IN VELOCITY AND THE RESULTING APPLIED FORCE ACTING UPON THE OBJECT THROUGH CAREFUL STUDY OF MULTI-EXPOSURE PHOTOGRAPHS OF THE MOVING OBJECT. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 13
DO EXPERIMENTS 20 AND 21. EXPERIMENT 20: CHANGES IN VELOCITY WITH A CONSTANT FORCE USES THE TICKER TIMER TO PROVIDE A RECORD OF THE CHANGE IN VELOCITY OF A SMALL CART. EXPERIMENT 21: THE DEPENDENCE OF ACCELERATION ON FORCE AND MASS- USES THE SAME EQUIPMENT AS EXPERIMENT 20.

STEP 14
TURN IN WRITEUPS ON EXPERIMENT 20 AND EXPERIMENT 21, AS THE EXERCISE SUGGESTS USE THIS APPARATUS TO DETERMINE THE MASS OF A CHUNK OF LEAD. WHAT KIND OF UNITS WILL YOU USE?

STEP 15
STUDY SECTIONS 19-3 AND 19-4 IN YOUR TEXT.

STEP 16
LISTEN TO THE TAPED DISCUSSION OF THE MATERIAL IF YOU DESIRE SOME ADDITIONAL HELP ON INTERPRETING THE READING ASSIGNMENT. THIS TAPE IS LABELED 19-3-B.

STEP 17
IS THERE ANOTHER STUDENT WITH WHOM YOU LIKE TO RAP? ASK HIM IF HE CAN EXPLAIN TO YOU THE RELATION BETWEEN THE FORCE APPLIED TO AN OBJECT AND THE RESULTING VELOCITY.

STEP 18
WORK PROBLEMS 8, 10, 11 AT THE END OF THE CHAPTER. CHECK ANSWERS IN HOMEWORK NOTEBOOK AND THEN TURN IN PROBLEMS FOR RECORDING PURPOSES.

STEP 19
ARRANGE TO COME IN FOR STUDY HELP IF YOU FEEL THAT IT WOULD BE BENEFICIAL TO YOU.

STEP 20
CONSIDER THIS QUESTION CONCERNING FORCES: A HORSE IS HITCHED TO A WAGON WITH A ROPE. THE HORSE PULLS ON THE ROPE WITH A FORCE, F. THE ROPE, THEN, PULLS ON THE HORSE WITH A FORCE, F. THEN WHY IS IT THAT THE WAGON STARTS TO MOVE?

STEP 21
IF YOU HAVE ANY QUESTIONS AT THIS POINT---BUG MR. DAILY---DON'T LET HIM GET AWAY THIS TIME.

STEP 22
STEP 23
THE CONTENT OF THIS OBJECTIVE IS RELATED TO: MOTION OF AN OBJECT WHEN THE MASS OF THE OBJECT CHANGES WHILE A CONSTANT FORCE IS APPLIED TO IT. I WILL BE ABLE TO OUTLINE THE CHARACTERISTICS OF INERTIAL AND GRAVITATIONAL MASS THAT ARE SIMILAR (ADDITIVE MASSES, UNITS, CONSERVATION DURING CHEMICAL CHANGE, VOLUME OF SUBSTANCE) AND DISTINGUISH WHY INERTIAL AND GRAVITATIONAL MASS ARE NOT THE SAME. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 24
DO EXPERIMENT 22 'INERTIAL AND GRAVITATIONAL MASS'. THIS LAB IS RECOMMENDED AFTER READING SECTIONS 19/5-19/6 IN THE TEXT.

STEP 25
REFER SPECIFICALLY TO THE PORTION OF THE LAB WHICH DELVED INTO THE PROBLEM OF WHETHER GRAVITY PLAYS A PART IN THE OPERATION OF THE INERTIAL BALANCCE IN YOUR WRITE-UP.

STEP 26
READ SECTIONS 19/5-19/6 IN THE TEXT. AN OPTIONAL READING ON MASS IS THE ARTICLE 'NEGATIVE MASS' WHICH IS LOCATED IN THE PROJECT PHYSICS READER #2 (PAGES 207-211).

STEP 27
LISTEN TO TAPE 19-2-B FOR THE SUMMARY OF SECTIONS 19/5-19/6.

STEP 28
GO TO A CLASSMATE AND ASK HIM IF HE CAN EXPLAIN THE DIFFERENCE BETWEEN INERTIAL AND GRAVITATIONAL MASS. TRY TO DISTINGUISH BETWEEN THE TYPES OF MASS TO THE EXTENT YOUR OBJECTIVE FOR THIS SECTION IS SATISFIED.

STEP 29
STUDY THE PROGRAMMED MATERIAL FROM SECTION 1 -GRAVITATIONAL AND INERTIAL MASS (PAGES 134-137). CHECK WITH MR. DAILY ON THE LOCATION OF THIS MATERIAL.

STEP 30
DO PROBLEMS 15, AND 17. THESE QUESTIONS FOCUS UPON THE INERTIAL MASS-GRAVITATIONAL MASS DISTINCTION.

STEP 31
IF YOU NEED TO SPEND ADDITIONAL TIME IN THE PHYSICS ROOM, ARRANGE TO DO SO WITH MR. DAILY. AFTER SCHOOL IS A GOOD TIME FOR:

1. TALKING WITH YOUR TEACHER.
2. TAKING PRE AND POSTTESTS.
3. WORKING IN THE LAB.

STEP 32
IF YOU WOULD LIKE MR. DAILY TO SUMMARIZE THE CONCEPTS THAT YOU HAVE STUDIED IN MECHANICS TO THIS POINT CONTACT HIM ABOUT PRESENTING A LECTURE ON THE TOPICS COVERED THUS FAR.

STEP 33
GRAB YOUR TEACHER AND PIN HIM DOWN WITH ANY QUESTIONS YOU MAY STILL HAVE ON 'MASS'.

STEP 34
STEP 35
THE CONTENT OF THIS OBJECTIVE IS RELATED TO NEWTON'S LAW AND THE UNIT OF FORCE. I WILL BE ABLE TO SOLVE COMPLEX DYNAMICS PROBLEMS WHICH REQUIRE AN INITIAL SOLUTION TO YIELD THE DATA TO SOLVE THE PRIMARY PROBLEM. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE

THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 36
SEE MR. DAILY FOR INSTRUCTIONS ON CONDUCTING TWO ADDITIONAL LAB EXERCISES. ONE EXERCISE IS PERFORMED WITH A FORCE TABLE, AND THE OTHER REQUIRES VERY INTRICATE EQUIPMENT SUCH AS: BLOCK, STRING, CHALK DUST.

STEP 37
HAND IN A BRIEF WRITE-UP OF THIS INVESTIGATION.

STEP 38
READ SECTIONS 19/7-19/8 OF THE TEXT. IN ADDITION REFER TO PHYSICS PROJECT READER #2 FOR THE ARTICLE 'NEWTON AND THE PRINCIPIA'. THIS ARTICLE, DESCRIBES ONE OF THE HUMAN CONFLICTS THAT NEWTON ENCOUNTERED DURING THE TIME HE WAS DEVELOPING HIS IDEAS ON DYNAMICS.

STEP 39
IF YOU FEEL THE NEED, SECTIONS 19/7-19/8 ARE SUMMARIZED ON THE TAPE LABELED 19-7-8.

STEP 40
CHECK WITH A FRIEND OR FOE(IF YOU FEEL LIKE ARGUING) TO SEE IF YOU CAN EXPLAIN TO HIM HOW A UNIT OF FORCE IS ESTABLISHED.

STEP 41
STUDY THE PROGRAMMED MATERIAL IN SECTION 10 -MKS UNITS OF FORCE (PAGES 117-119). CHECK WITH MR. DAILY ON THE LOCATION OF THIS MATERIAL.

STEP 42
WORK PROBLEMS 20,21 AND 22.

STEP 43
SEEK MR. DAILY OUT IF YOU FEEL THE NEED.

STEP 44
SOLVE THIS PROBLEM: A 700 KG CAR TRAVELING 5 M/S COLLIDES WITH A BARRIER. IF THE CAR MOVES .3 METER BEFORE COMING TO A STOP, WHAT AVERAGE FORCE DOES THE CAR EXERT ON THE BARRIER? ANSWER=1460 NEWTONS

STEP 45
STEP 46
THE CONTENT OF THIS OBJECTIVE IS RELATED TO FORCE VECTORS AND NEWTON'S LAW. I WILL BE ABLE TO DEVISE A FORCE VECTOR DIAGRAM TO DESCRIBE ALL THE VECTOR COMPONENTS ACTING UPON A PROJECTILE MOVING THROUGH THE EARTH'S ATMOSPHERE. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND

WRITTEN.

STEP 47
READ SECTIONS 19/9-19/11 IN THE TEXT. A NUMBER OF SELECTIONS IN THE PROJECT PHYSICS READER #2 ARE APPROPRIATE AT THIS POINT. READ AT LEAST ONE OF THE FOLLOWING SELECTIONS: THE DYNAMICS OF A GOLF CLUB (PAGES 126-129), BAD PHYSICS IN ATHLETIC MEASUREMENT (PAGES 131-136), THE SCIENTIFIC REVOLUTION (PAGES 139-146), HOW THE SCIENTIFIC REVOLUTION OF THE SEVENTEENTH CENTURY AFFECTED OTHER BRANCHES OF THOUGHT (PAGES 147-155).

STEP 48
TAPE 19-9-B SUMMARIZES THE READING SELECTIONS FROM THE TEXT AND MODERN PHYSICS TEXT. THIS TAPE ALSO REINTERATES THE BASIC CONCEPTS OF THE ENTIRE CHAPTER.

STEP 49
DISCUSS THIS PROBLEM WITH ANOTHER MEMBER OF CLASS; HOW IS FRICTION TAKEN INTO ACCOUNT IN THE SOLUTION OF DYNAMICS PROBLEMS?

STEP 50
BRIEFLY STUDY THE PROGRAMMED MATERIAL AND ACCOMPANYING PANELS FROM SECTION 9 -NEWTON'S SECOND LAW OF MOTION (PAGES 107-116).

STEP 51
SOLVE PROBLEMS 29, 30, AND 33.

STEP 52
IF YOU ARE HAVING ANY PROBLEMS WITH THE READING ASSIGNMENTS, LABORATORY EXERCISES, OR MATH PROBLEMS BY ALL MEANS SEE MR. DAILY.

STEP 53
CHECK WITH MR. DAILY ABOUT THE NEED FOR A LECTURE THAT SUMMARIZES AND CONNECTS THE MAIN CONCEPTS OF CHAPTER 19 TO THE OBJECTIVES THAT YOU ARE WORKING TOWARD.

STEP 54
ARRANGE TO SEE MR. DAILY IF YOU FEEL THE NEED FOR EITHER EXTRA TIME OR ASSISTANCE.

STEP 55
STEP 56
ARRANGE TO TAKE THE POSTEST FOR CHAPTER 19. SEE YOUR TEACHER FOR THE PROPER TEST FORM.

IF YOUR SCORE ON THE POST TEST IS NOT UP TO THE STANDARDS THAT YOU AND YOUR TEACHER HAVE AGREED UPON, THEN YOU SHOULD RECYCLE THROUGH THAT MATERIAL WITH WHICH YOU HAD DIFFICULTY.

PHYSICS

MOTION AT THE EARTH'S SURFACE
CHAPTER 20

THIS STUDY GUIDE IS PRINTED
ESPECIALLY FOR DALE BIVENS

ROUTE 3

COLUMBIA, MISSOURI
65201

FIRST SEMESTER

1971

DAVID H. HICKMAN HIGH SCHOOL

NORTH HALL ROOM 110

TEACHER: MR. WILLIAM DAILY

MOTION AT THE EARTH'S SURFACE
CHAPTER 20

THIS IS A SPECIAL INDIVIDUALIZED PROGRAM WRITTEN FOR DALE BIVENS.

DALE, THIS GUIDE HAS BEEN PREPARED FOR YOU USING INFORMATION FROM THE TESTS ADMINISTERED DURING THE INITIAL WEEKS OF SCHOOL AND YOUR PAST PERFORMANCE IN SCIENCE AND MATHEMATICS. THE TASKS RECOMMENDED IN THIS GUIDE SHOULD BE INTERESTING AND CHALLENGING. THE ACTIVITIES, PROBLEMS, LABS, FILMS AND READING MATERIALS THAT ARE SUGGESTED SHOULD ASSIST YOU GREATLY IN UNDERSTANDING THE BASIC IDEAS OF MECHANICS.

INDEX NUMBERS				TIME ALLOWED
1	1	1	2	1.1 X THE TEACHER'S GUIDE FIGURE

SINCE THIS GUIDE COVERS ONE CHAPTER, FOR YOU TO COMPLETE IT WILL PROBABLY REQUIRE 16 DAYS.

THOUGH SOME OF THE PHYSICS STUDENTS WILL PROBABLY GO ELSEWHERE TO STUDY WILL YOU PLEASE STAY IN ROOM 110 SO MR. DAILY MAY ASSIST YOU WHEN IT SEEMS NECESSARY.

ARRANGE TO TAKE THE PRETEST FOR CHAPTER 20, MOTION AT THE EARTH'S SURFACE.

OBJECTIVES FOR THIS CHAPTER

1. THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE DISTINCTION BETWEEN MASS AND WEIGHT. I WILL BE ABLE TO:
 A. DIFFERENTIATE THE REASONS FOR DIFFERENT GRAVITATIONAL CONSTANT VALUES AT DIFFERENT LOCATIONS ON THE EARTH'S SURFACE:
 B. DIAGRAM THE GRAVITATIONAL FORCE COMPONENT ON OBJECTS IN MOTION AND DETERMINE GRAVITATIONAL FORCE'S EFFECT UPON THAT MOTION. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

2. THE CONTENT OF THIS OBJECTIVE IS RELATED TO VERTICAL MOTION AS IT APPLIES TO NEWTON'S LAW. I WILL BE ABLE TO COMPARE THE COMMON CHARACTERISTICS OF OBJECTS IN FREE FALL TO OBJECTS MOVING OVER A HORIZONTAL SURFACE WITH A CONSTANT FORCE APPLIED. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

3. THE CONTENT OF THIS OBJECTIVE IS RELATED TO NEWTON'S LAW AND PROJECTILE MOTION. I WILL BE ABLE TO:

A. SOLVE PROBLEMS INVOLVING TRAJECTORIES OF PROJECTILES WITH ADDITIONAL FORCE COMPONENTS INJECTED (I.E. FRICTIONAL FORCES, AIR RESISTANCE);

B.DIAGRAM THE GRAVITATIONAL FORCE COMPONENTS PARALLELAND PERPENDICULAR TO THE PATH OF THE OBJECT AT DIFFERENT STAGES OF ITS FLIGHT. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

4. THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE APPLICATION OF NEWTON'S LAW TO UNIFORM CIRCULAR MOTION. I WILL BE ABLE TO:

A. DEMONSTRATE CIRCULAR MOTION AND DESCRIBE THE FORCES ACTING UPON THE OBJECT AS IT REVOLVES;

B. MODIFY AND APPLY THE FOLLOWING EQUATIONS TO CALCULATE THE PERIOD AND VELOCITY OF AN ARTIFICIAL SATELLITE. (V=2KR/T, A=V2/R, F=MV2/R) I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

5. THE CONTENT OF THIS OBJECTIVE IS RELATED TO SIMPLE HARMONIC MOTION. I WILL BE ABLE TO USE THE EQUATIONS (F=-KX, T=2PISQRT(M/K), T=2PISQRT(L/G)) TO DETERMINE THE PERIOD AND DISPLACEMENT OF A PENDULUM. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

6. THE CONTENT OF THIS OBJECTIVE IS RELATED TO FRAMES OF REFERENCE. I WILL BE ABLE TO DIAGRAM THE FORCES ACTING UPON AN OBJECT IN A NONINERTIAL FRAME OF REFERENCE AND THE SAME EXAMPLE FROM AN INERTIAL FRAME OF REFERENCE. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP I

1. THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE DISTINCTION BETWEEN MASS AND WEIGHT. I WILL BE ABLE TO:

A. DIFFERENTIATE THE REASONS FOR DIFFERENT GRAVITATIONAL CONSTANT VALUES AT DIFFERENT LOCATIONS ON THE EARTH'S SURFACE:

B. DIAGRAM THE GRAVITATIONAL FORCE COMPONENT ON OBJECTS IN MOTION AND DETERMINE GRAVITATIONAL FORCE'S EFFECT UPON THAT MOTION. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 2
READ SECTION 20/1. THE PURPOSE OF THIS SECTION IS TO DISTINGUISH BETWEEN MASS AND WEIGHT. DOES THIS RELATE THE OBJECTIVE STATED IN THE PRECEEDING STEP?

STEP 3
TAPE 20-1-B IS AVAILABLE FOR YOU, IT SUMMARIZES SECTION 20/1.

STEP 4
ASK A CLASSMATE TO CALCULATE YOUR OR HIS WEIGHT IN NEWTONS.

STEP 5
WORK PROBLEMS 1,2, AND 3 AT THE END OF CHAPTER 20. CHECK YOUR ANSWERS IN HOMEWORK NOTEBOOK THEN TURN THE PAPERS IN FOR RECORDING PURPOSES.

STEP 6
IF YOU ARE UNABLE TO DISTINGUISH BETWEEN MASS AND WEIGHT YOU SHOULD SEE MR. DAILY FOR A STUDY-HELP SLIP.

STEP 7
IF YOU HAVE PROCEEDED THROUGH THE READING ASSIGNMENT, LISTENED TO THE TAPE RELATED TO THIS SECTION, AND STILL DO NOT FEEL YOU ADEQUATELY CAN DISTINGUISH BETWEEN THE CONCEPTS OF MASS AND WEIGHT SEE MR. DAILY.

STEP 8
STEP 9
2. THE CONTENT OF THIS OBJECTIVE IS RELATED TO VERTICAL MOTION AS IT APPLIES TO NEWTON'S LAW. I WILL BE ABLE TO COMPARE THE COMMON CHARACTERISTICS OF OBJECTS IN FREE FALL TO OBJECTS MOVING OVER A HORIZONTAL SURFACE WITH A CONSTANT FORCE APPLIED. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 10
THE FILM-'FALLING BODIES' IS SCHEDULED FOR THIS WEEK. THIS FILM UTILIZES NEWTON'S LAW AND THE OBSERVED PHENOMENA OF CONSTANT ACCELERATION OF FALLING BODIES TO SHOW THE RELATIONSHIP BETWEEN GRAVITATIONAL AND INERTIAL MASS. CHECK WITH MR. DAILY FOR THE DATE OF SHOWING OF THIS FILM.

STEP 11
READ SECTION 20/2 FROM THE TEXT AND PARAGRAPHS 8,9, AND 10 (PAGES 83-84) IN 'MODERN PHYSICS'.

STEP 12
LISTEN TO TAPE 20-2-B FOR A SUMMARY OF THE CONTENT COVERED IN THIS SECTION(20/2).

STEP 13
ASK A FELLOW STUDENT TO EXPLAIN WHAT WOULD HAPPEN IF A LIGHTBULB WERE THROWN DOWNWARD FASTER THAN THE TERMINAL VELOCITY OF THE BULB.

STEP 14
SOLVE PROBLEMS 7,8, AND 10 AT THE END OF CHAPTER 20 IN THE TEXT.

STEP 15
IF YOU ARE EXPERIENCING DIFFICULTY WITH THE PROBLEMS SEE MR. DAILY FOR HELP.

STEP 16
TRY THIS SIMPLE EXERCISE: FIRST TAKE A BOOK AND A SHEET OF PAPER, HOLD THEM SIDE BY SIDE AND DROP THEM SIMULTANEOUSLY. EXPLAIN WHAT HAPPENS.
SECOND HOLD THE PAPER ABOVE THE BOOK (LYING ON THE BOOK) MAKE SURE THE PAPER'S EDGES DO NOT EXTENT BEYOND THE EDGES OF THE BOOK. THEN DROP BOTH(BOOK-PAPER) SIMULATANEOUSLY. WHAT HAPPENS? WHY?

STEP 17
IF THE FILM 'FALLING BODIES' HAS NOT BEEN SHOWN, CHECK WITH MR. DAILY AGAIN TO SEE WHEN IT WILL BE SHOWN.

STEP 18
NEED HELP? SEE MR. DAILY; PERSIST UNTIL YOU GET YOUR QUESTIONS ANSWERED.

STEP 19
STEP 20
3. THE CONTENT OF THIS OBJECTIVE IS RELATED TO NEWTON'S LAW AND PROJECTILE MOTION. I WILL BE ABLE TO:
A. SOLVE PROBLEMS INVOLVING TRAJECTORIES OF PROJECTILES WITH ADDITIONAL FORCE COMPONENTS INJECTED (I.E. FRICTIONAL FORCES, AIR RESISTANCE);
B.DIAGRAM THE GRAVITATIONAL FORCE COMPONENTS PARALLELAND PERPENDICULAR TO THE PATH OF THE OBJECT AT DIFFERENT STAGES OF ITS FLIGHT. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 21
READ SECTIONS 20/3-20/4 IN THE TEXT. THESE SECTIONS PERTAIN SPECIFICALLY TO PROJECTILE MOTION.

STEP 22
PLEASE LISTEN TO TAPE 20-3-B. THIS TAPE SUMMARIZES AND EXTENDS SOME IDEAS CONCERNING PROJECTILE MOTION.

STEP 23
ASK ANOTHER PHYSICIST(IN CLASS) TO EXPLAIN THE STATEMENT: THE MOST IMPORTANT ASPECT OF PROJECTILE MOTION IS THE INDEPENDENCE OF THE COMPONENTS.

STEP 24
SOLVE PROBLEMS 13, AND 14 AT THE END OF THE CHAPTER.

STEP 25
GETTING BEHIND? MAKE AN APPOINTMENT WITH YOURSELF TO STUDY PHYSICS TONIGHT.

STEP 26
CHECK WITH OTHER STUDENTS ON THE NEED FOR A TEACHER LECTURE ON PROJECTILE MOTION. IF THERE IS AN INTEREST LET HIM KNOW ABOUT IT.

STEP 27
SEE MR. DAILY IF THERE IS ANY PROBLEM THAT SEEMS TO PERSIST. THAT'S WHAT HE'S HERE FOR.

STEP 28
STEP 29
4. THE CONTENT OF THIS OBJECTIVE IS RELATED TO THE APPLICATION OF NEWTON'S LAW TO UNIFORM CIRCULAR MOTION. I WILL BE ABLE TO:
 A. DEMONSTRATE CIRCULAR MOTION AND DESCRIBE THE FORCES ACTING UPON THE OBJECT AS IT REVOLVES;
 B. MODIFY AND APPLY THE FOLLOWING EQUATIONS TO CALCULATE THE PERIOD AND VELOCITY OF AN ARTIFICIAL SATELLITE. (V=2KR/T, A=V2/R, F=MV2/R) I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 30
DO LAB 24-CENTRIPETAL FORCE-. DO THIS LAB PRIOR TO READING THE ASSIGNMENT LISTED BELOW.

STEP 31
TURN IN THE WRITE-UP OF LAB 24. IN THE WRITE-UP BE SURE TO INCLUDE A RESPONSE TO THE QUESTION: WHAT IS THE DEPENDENCE OF THE CENTRIPETAL FORCE ON THE FREQUENCY WHEN THE REVOLVING MASS AND THE MASS ARE KEPT CONSTANT.

STEP 32
READ SECTIONS 20/5-20/7 IN THE TEXT. THERE ARE SEVERAL IMPORTANT CONCEPTS IN THIS ASSIGNMENT, AMONG THEM:
 A. A CONSTANT FORCE, ACTING PERPENDICULAR TO THE MOTION, PRODUCES UNIFORM CIRCULAR MOTION.
 B. THE PERPENDICULAR FORCE TO THE DIRECTION OF MOTION LEADS TO A PERPENDICULAR ACCELERATION WHICH CHANGES THE DIRECTION OF THE VELOCITY WITHOUT CHANGING ITS MAGNITUDE.

STEP 33
LISTEN TO TAPE 20-5-B FOR A BRIEF EXPLANATION OF CENTRIPETAL FORCE.

STEP 34
ASK SOMEONE IN CLASS TO EXPLAIN TO YOU WHAT FORCE MAKES A CAR GO AROUND A CORNER.

STEP 35
PROBLEMS 17, 18, 21 ARE FOR THE MATERIAL IN SECTIONS 20/5-20/7. WORK THESE PROBLEMS AND TURN THEM IN FOR RECORDING PURPOSES.

STEP 36
DO YOU NEED A STUDY-SLIP FOR ADDITIONAL LAB TIME, OR CONFERENCE TIME?

STEP 37
MR. DAILY WOULD BE GLAD TO DISCUSS ANY PROBLEM YOU MAY BE HAVING AT THIS POINT--GO BUG HIM.

STEP 38
STEP 39
5. THE CONTENT OF THIS OBJECTIVE IS RELATED TO SIMPLE HARMONIC MOTION. I WILL BE ABLE TO USE THE EQUATIONS (F=-KX, T=2PISQRT(M/K), T=2PISQRT(L/G)) TO DETERMINE THE PERIOD AND DISPLACEMENT OF A PENDULUM. I WILL BE EXPECTED TO DEMONSTRATE 90 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 40
READ SECTION 20/8 IN THE TEXT. THIS SECTION DISCUSSES SIMPLE HARMONIC MOTION BY RELATING IT TO A PROJECTION OF CIRCULAR MOTION.

STEP 41
TAPE 20-8-B IS A SHORT TAPE ON HARMONIC MOTION; IT MAY BE OF HELP TO YOU.

STEP 42
WHAT DOES THE EQUATION F=-KX MEAN? DISCUSS THIS QUESTION WITH ANOTHER MEMBER OF CLASS.

STEP 43
WORK THE FOLLOWING THREE PROBLEMS ON HARMONIC MOTION: 26, 27, AND 31.

STEP 44
MAKE AN APPOINTMENT WITH YOURSELF TO STUDY PHYSICS TONIGHT.

STEP 45
A NUMBER OF DEMONSTRATIONS ARE POSSIBLE TO SHOW HARMONIC MOTION, HOWEVER, YOU SHOULD CHECK WITH MR. DAILY TO DETERMINE WHETHER A DEMONSTRATION WILL BE PERFORMED FOR THIS SECTION.

STEP 46
SEE MR. DAILY WITH THOSE THINGS YOU STILL DO NOT UNDERSTAND--HE IS EAGER TO HELP YOU.

STEP 47
STEP 48
6. THE CONTENT OF THIS OBJECTIVE IS RELATED TO FRAMES OF REFERENCE. I WILL BE ABLE TO DIAGRAM THE FORCES ACTING UPON AN OBJECT IN A NONINERTIAL FRAME OF REFERENCE AND THE SAME EXAMPLE FROM AN INERTIAL FRAME OF REFERENCE. I WILL BE EXPECTED TO DEMONSTRATE 80 % MASTERY OF THIS OBJECTIVE THROUGH EXPLANATIONS, AND PROBLEM SOLUTIONS BOTH ORAL AND WRITTEN.

STEP 49
THE FILM--FRAMES OF REFERENCE--HAS BEEN SCHEDULED. THIS FILM WILL CERTAINLY ADD TO YOUR UNDERSTANDING OF REFERENCE FRAMES. CHECK WITH MR. DAILY FOR THE VIEWING DATE.

STEP 50
THIS READING ASSIGNMENT CONCLUDES THE CONTENT OF CHAPTER 20. READ SECTIONS 20/9-20/11.

STEP 51
TAPE 20-9-B DISCUSSES FRAMES OF REFERENCE BRIEFLY, PLEASE LISTEN TO IT.

STEP 52
WHAT IS AN INERTIAL FRAME OF REFERENCE? DISCUSS THIS QUESTION WITH ANOTHER CLASSMATE THEN CHECK WITH OTHERS TO SEE IF COMMON AGREEMENT EXISTS.

STEP 53
SOLVE PROBLEMS 34, AND 39.

STEP 54
MR. DAILY WILL GLADLY SUMMARIZE THE TOPICS OF THIS CHAPTER. CHECK WITH HIM TO FIND OUT WHEN.

STEP 55
GO BUG MR. DAILY WITH A FORCE PROBLEM OR SOMETHING LIKE THAT.

STEP 56
STEP 57
ARRANGE TO TAKE THE POST-TEST FOR CHAPTER 20. SEE YOUR TEACHER FOR THE PROPER TEST FORM.

IF YOUR SCORE ON THE POST TEST IS NOT UP TO THE STANDARDS THAT YOU AND YOUR TEACHER HAVE AGREED UPON, THEN YOU SHOULD RECYCLE THROUGH THAT MATERIAL WITH WHICH YOU HAD DIFFICULTY.